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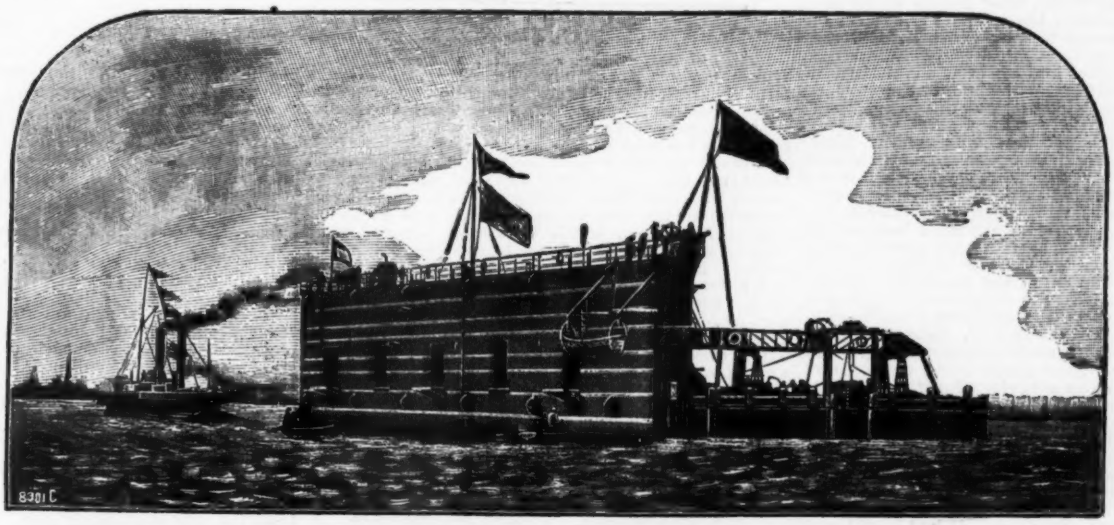
NEW FLOATING DOCK.

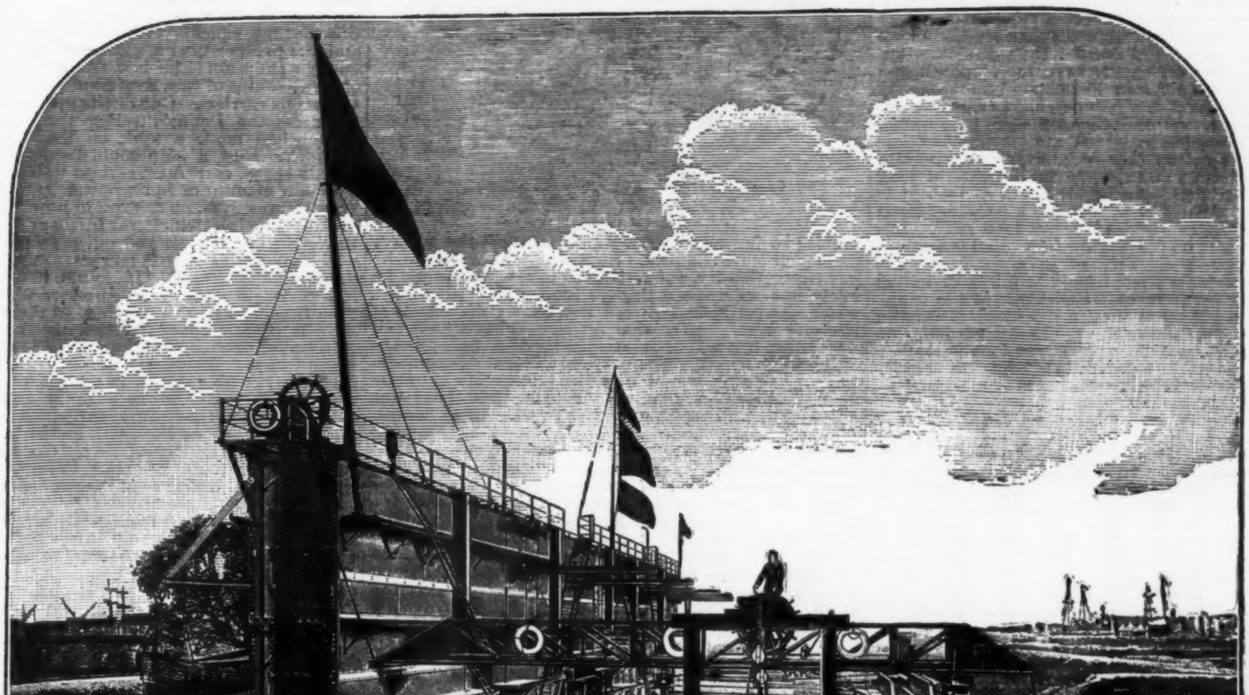
WE illustrate the off-shore floating dock for the Dumfries Dry Dock, Ship Building, and Engineering Company, Limited, of Cardiff, constructed by Messrs. Clark and Standfield, at Grays, near Tilbury. Owing to various stoppages and local causes, the preparation of the site has occupied very much longer than it was expected to do; but as the work is now nearly completed, the dock has been towed to Cardiff, ready to be connected to the shore columns as soon as they are erected. On the morning of the 24th of June the dock was floated, and at 3 P.M. it was hauled out of the builders' basin, and taken in tow by two powerful tugs, viz., the Australia and the Anglia, of the Watkins line, and at once proceeded on the voyage. The upper illustration is taken from instantaneous photograph, and shows the dock just starting.

This novel form of dock in end elevation resembles the letter L, the horizontal limb or pontoon being larger than the vertical when in position for work. The upright side of the dock will be attached to the vertical columns on shore by means of six pairs of parallel motion booms, which insure the horizontality of the dock in all states of the tide. The lugs to which these booms are pinioned can be seen in the illustrations. Large gangways pass from the shore to the pontoon through the passages seen in the upright side.

The dock being lowered, a vessel is brought over it and rapidly centered by the mechanical side shores; pumping is then proceeded with till the vessel has a good bearing on the keel blocks; the adjustable bilge blocks are then brought into position and pumping resumed till the vessel is lifted clear of the water. The side shores and the bilge blocks are all worked from the top deck; automatic gear is fitted by which the dock is kept at almost a dead level, though simple means are provided for giving the dock a certain amount of inclination in any direction if desired to take up a vessel with a considerable list or on an uneven keel.

Every part of the dock can readily be got at for cleaning and painting.—*Engineering.*





OFF-SHORE FLOATING DRY DOCK FOR CARDIFF.

SHIP WAVES.

DURING the recent meeting of the Institution of Mechanical Engineers, at Edinburgh, an able and interesting lecture was delivered before the members and friends by Sir William Thomson, F.R.S., at the conversazione in the museum of science and art. Sir William, who was received with great cordiality, spoke for over an hour, illustrating his lecture by means of diagrams. Wave, he said, was a comprehensive word. It included waves of water, waves of light, waves of sound, and waves of matter such as are experienced in earthquakes. It comprehended even more than this—it might be de-

fined generally as the progression through matter of a state of motion. The distinction between the progress of matter from one place to another and the progress of a wave from one place to another was well illustrated by the largest example of waves we had (largest in one dimension, smallest in another), and that was waves of light, which extend from the remotest star, a million times as far away as the sun. Let them think of ninety million million miles, and let them think of waves of light coming from stars known to be as far away as that. So much for the distance of propagation, or progression, of light.

There was another magnitude concerning waves, two other magnitudes, he might say. There was the wave length, and the amount of displacement of the moving particle in a wave. The wave length from crest to crest in waves of light was from a thirty thousandth of an inch to a fifty or sixty thousandth of an inch. Waves of water had this great distinction from waves of light and sound, that they were manifested at the surface of the medium or substance whose motion constitutes the wave. It was with waves of water that they were concerned that night, and of all the beautiful forms of water waves, ship waves were the most beautiful—if they could compare waves for beauty—and certainly they were most interesting. For mathematical science the subject possessed a special and intense interest, partly from the difficulty of the problem, and partly from the peculiar complexity of the circumstances concerned in the configuration that was presented to view. He should, as included in his special subject of ship waves, refer first to waves in a canal, and to the results of the splendid researches on the subject made about 1834 by Scott Russell, and communicated to the Royal Society of Edinburgh. He had given a general and abstract definition of a wave; let them have it in the concrete, as the wave, or waves, produced by a boat dragged through a canal. In the rear of the boat there was a procession of waves, with which they had to deal in the first place. They must learn to understand this procession of waves in the rear of a canal boat before they could follow the forms of more complicated patterns that they saw in the wake of a ship traveling through open water at sea. The question he was going to ask was: How is this procession kept up? They knew it took power to drag a boat through a canal, but they did not all think on what part of the phenomena the power required to drag the boat depended. He asked them to think of water, not as it is, but as they could conceive the substance to be—that is, absolutely fluid. In reality, water is not perfectly fluid. It resists change of shape, and non-resistance to change of shape is the definition of a perfect fluid. Is water a perfect fluid? Is it a fluid at all? It is a fluid in the same sense as oil and treacle are fluids. It resists change of shape when the attempt to make the change is too rapid. When it is attempted to make the change very rapidly, there is a great resistance. If a change is made slowly, there is a small resistance. The resistance of fluids to change of shape is then proportional to the speed of the change. As a result of mathematical experiments it had been found that great waves would travel for hours or days without showing very much loss of sensible motion or energy through viscosity. On the other hand, let them look at the ripples on a pond excited by a puff of wind. The wind was no sooner gone than the ripples began to subside, and in a few seconds the pond was perfectly still and quiet. The forces as concerned in short waves, like ripples, and the forces as concerned in long waves, such as they saw on the open sea, are so related to time and speed that in the case of short waves viscosity comes to be very potent, while in the case of long waves it is little felt. Asking them to allow him to assume that water was a perfect fluid, he endeavored to point out where viscosity comes into play. The velocity of progression of a wave in a canal is smaller, the shorter the wave. That of a very long wave is equal to the velocity that a body acquires in falling from a height equal to half the depth of the canal. For instance, a body fell from a height of 16 ft., and acquired a velocity of 32 ft. a second. A body fell from a height of 4 ft., and the velocity was only 16 ft. a second. Therefore, in a canal 8 ft. deep, the velocity of the "long wave" is 16 ft. per second.

v. Velocity of wave in knots per hour.	λ Wave length, in feet.	v. Velocity of wave in knots per hour.	λ Wave length, in feet.
6	19·513	17	156·646
7	26·559	18	175·618
8	34·690	19	195·672
9	43·904	20	216 812
10	54·203	22	262·343
11	65·585	24	312·209
12	78·052	26	366·412
13	91·602	28	424·952
14	106·238	30	487 827
15	121·956	35	663·987
16	138·760	40	867·248

If water were a perfect fluid, this would be the case: A body dragged along at any velocity less than the speed of a long wave in the canal would leave a train of waves behind it of such short length that their velocity of propagation is equal to the velocity of the boat. In relation to the boat, what was a wave? It was the progression of a state of motion, and motion could not take place without displacement of the particles. A wave was the progression of a displacement. Let them observe a field of corn on a windy day. They would see something traveling over it. It was not the ears of corn carried from one side of the field to the other. The bending down of the stalks was what traveled. He described how a wave might be made. On the surface of a canal let there be used a plastic material modeled in any form. Let this material be placed on the surface, taking care that the water filled up the form everywhere, leaving no air in the upper bends. Thus they had a standing displacement of the water from its level. Let this form, thus shaping the surface, be dragged along the canal, and a wave would be produced. To find the velocity of the progress of a free wave, first remark that when the form was at rest the pressure was greater at the hollow and less at the crest. If the form were moved along very rapidly, a certain result of inertia of the flowing water would cause pressure to be greatest at crest and least at lowest point of hollow. But if the form were moved along at exactly the proper speed, the pressure would be equal over the surface of the form. Annul now the rigidity of the form, and thus there would be a free wave.

The question occurred to every one who thought of these things in an engineering way: How is the wave procession kept up, or does it require to be kept up? He pointed out that the forming of the procession of waves once accomplished, it might seem that there was nothing more to be desired in the way of work. Let the procession be formed, and it would go on itself. Any one who makes a voyage in a steamer should look astern, and he will see the waves spreading out beautifully. The rear end of the procession of waves would be seen to follow the steamer. In a canal, the phenomenon was more simple than on the sea. The velocity of the progress of a wave was one thing, the velocity of the front of a procession of waves and of the rear of a procession of waves was another. water, supposed inviscid, would go on forever if it were not forming a procession of waves behind it, that is, if the boat have a velocity greater than the velocity of the wave speed on the canal, and in these circumstances, ideal so far as nullity of viscosity is concerned, it would travel along and continue moving without any work being done at all. Scott Russell was not satisfied with mere experimental observation, and so an investigation was conducted on the Forth and Clyde Canal (see Fig. 1). A boat called the Raith was one of those for which he measured the forces to drag it at different speeds. The depth of the canal was about $4\frac{1}{2}$ ft. or 5 ft., and the weight of the Raith was 10,239 lb. At different speeds it took the following forces to drag it along: At $4\frac{3}{4}$ miles an hour, 112 lb.; at $5\frac{8}{15}$ miles an hour, 261 lb.; at $6\frac{2}{15}$ miles an hour, 275 lb. Thus at nine miles an hour the force required was 250 lb., being less than at those lower speeds. The speed of the long wave for these results was eight miles

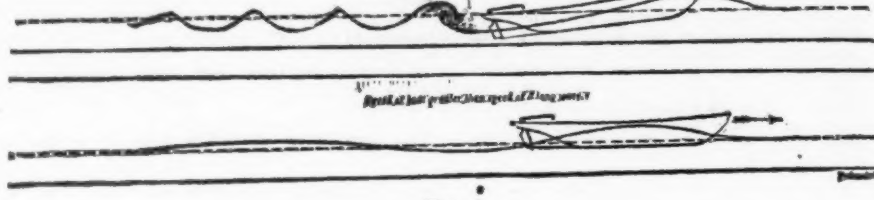


FIG. 1.

Stokes made a grand new opening in this department of work, never before thought of. As was his manner, he did it merely in an examination paper for the Smith prize at Cambridge University. He did not remember the year, and he did not know if any of the candidates answered the question that was put. He knew that the question was put, and that it was answered with good effect by Osborne Reynolds in a contribution to the British Association, and published also in *Nature*, in which he argued out one great branch, at all events, of the theory propounded by Stokes. Reynolds made the doctrine and idea active, and a few years later Lord Rayleigh took the matter up and generalized in the most admirable manner, laying the foundation of the whole theory of velocity of groups of waves. These researches offered the explanation of wave-making resistance to ships, whether in a canal or at sea. In the first place, the doctrine of energy might be explained in reference to waves in

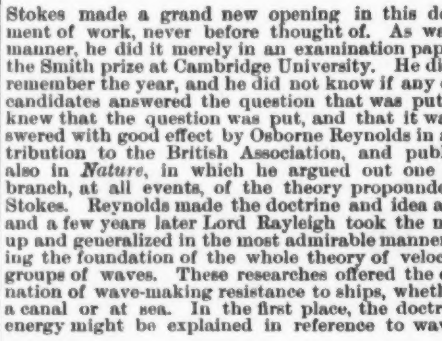


FIG. 2.

canals; so far as the sea was concerned, the subject was much more complex. Supposing the water to be free from viscosity, the resistance to the boat would be solely due to wave making. In a canal, where the water was confined between two banks, the effects of viscosity were greater than at sea. They would call water deep if it was of greater depth than three-fourths of the wave length. The progression of the rear of the wave procession would, in water "deep" as thus defined, be half the speed of the boat. The boat was followed by an ever-lengthening procession of waves. Were the water free from viscosity, the work required to drag the boat along would be equal to the work required to develop this procession of waves lengthening behind the boat at half the speed of the boat. The rear of the procession traveled at half the speed of the boat, and the procession lengthened relatively to the boat backward at half the speed of the boat. If the motion of a canal boat was more rapid than the quickest possible wave in the canal (that is the "long wave"), it could not leave behind it a wave procession at all. It could only make a hump or hillock traveling with the boat. A boat started moving through the

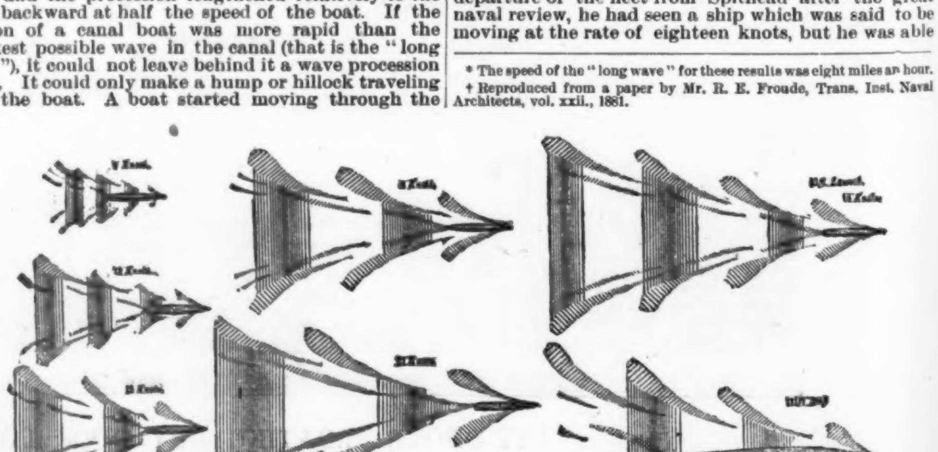
an hour. At $10\frac{1}{2}$ miles there was again an increase to 268 lb. If water were supposed to be a perfect fluid, then at any speed above eight miles per hour (the speed of the long wave) there would have been no resistance. There were still more remarkable figures shown by another boat, which, with its load, weighed 12,579 lb. The forces required for different speeds being as follow:*

	lb.
At 6·2 miles an hour	250
" 7·6 " "	500
" 8·5 " "	400
" 9·0 " " only	280

It could not be said on mechanical grounds that canal traffic could compete for speed with traffic by railway. He next called attention to the most beautiful and most difficult, and, in some respects, most interesting, part of his subject, and that was the pattern of waves caused by a ship at sea (see Figs. 2, 3, and 4).† This point of the subject had been argued out with wonderful power by William Froude, whose son was at present engaged in the same work. The Admiralty had taken up the subject, and made it a department of their experimental work. The younger Froude inherited a large measure of his father's genius, perseverance, and mechanical skill. His father and he had succeeded in obtaining results of the highest practical importance. It was an important matter indeed for this country, which depended so much on ship building and the prosperity and success of its ship builders, to find the shapes of ships best adapted for different kinds of work—ships of war, carriers of passengers and mails, and goods carriers. One of the great Clyde ship building firms, the Dennys, feeling the importance of the matter, had made a tank on the same plan as Mr. Froude's. Now a ship could be designed to go at a certain speed, carrying a certain weight, and requiring a certain amount of horse power to work the engines. The lecturer went on to explain how, by following out Stokes' principle, which was further developed by Lord Rayleigh, he had worked out a mathematical theory which allowed him to construct a model of the wave procession (see Fig. 5). He found that the whole pattern of waves was comprised between two lines drawn from the bow of a ship inclined to the wake on its two sides at equal angles of 19° 28′. If they thought of a ship traveling over water, they would ask: How does it make a wave? Where was the ship when it gave rise to the wave? The wave at a certain place was due to what the ship did to the water at another place. In this connection the lecturer explained some very interesting diagrams (see Figs. 6, 7, and 8) lent him by Mr. W. H. White, Director of Naval Construction for the Admiralty, and Mr. Edmund Froude. He explained that by the appearance of its waves one could learn the speed at which a ship was going. Recently, at the departure of the fleet from Spithead after the great naval review, he had seen a ship which was said to be moving at the rate of eighteen knots, but he was able

* The speed of the "long wave" for these results was eight miles an hour.

† Reproduced from a paper by Mr. R. E. Froude, Trans. Inst. Naval Architects, vol. xxii., 1881.


FIGS. 3 AND 4.

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from the waves to know that it was not moving at more than twelve knots. He explained by diagrammatic illustration (Figs. 3 and 4) the respective characteristics of waves caused by a torpedo launch as differing from waves caused by ships and boats.

He wished to speak about the question of the effect of a ship's build in causing ship waves. As he remembered ship building on the Clyde first, sometimes after a vessel was put into the water, and found to be drawing too much water forward or aft, it was taken out of the water and a piece put into its middle. Sometimes also a ship was lengthened, with a view to add to its speed. Mr. Froude took up this question of parallel middle body, and found that a ship with a long parallel body, or indeed any ship at all, but more particularly one with a parallel middle body, showed curious phenomena of resistance at different speeds. As speed was raised the resistance increased, and then it seemed as if it would begin to diminish. It never quite diminished, however, but increased at a much less rate when rising to the speed at which the effect of the entrance or bow of a ship and the effect of the run or stern is skin resistance of 6·6 and a wave resistance of 6·15. In the case of another ship, of 3,626 tons displacement, going at 13 knots, the skin resistance was 6·95 tons and the wave resistance only 2·45. At a speed of 14 knots there was a remarkable result, skin resistance being 8 tons, wave resistance only 3·15. In a torpedo boat 125 ft. long, with a speed of 20 knots, the skin resistance was 1·2 tons and the wave resistance 1·1—the total resistance 2·3. Sir William then offered what he called his little suggestion, and he offered it with exceeding diffidence. Wave-making resistance depended almost entirely on surface action. Inasmuch as a fish swimming close to the surface caused little wave disturbance, it seemed to him that by giving a great deal of body below the water line of a ship we might diminish the wave-making resistance very much. By swelling out the ship below water 3 ft. or 4 ft. or 5 ft., like the old French war ships, there would be a large addition to the carrying power of the ship, and but little addition to the disturbance made at high speeds. This point he thought worthy to be considered in the future designing of ships. In conclusion he asked all his hearers

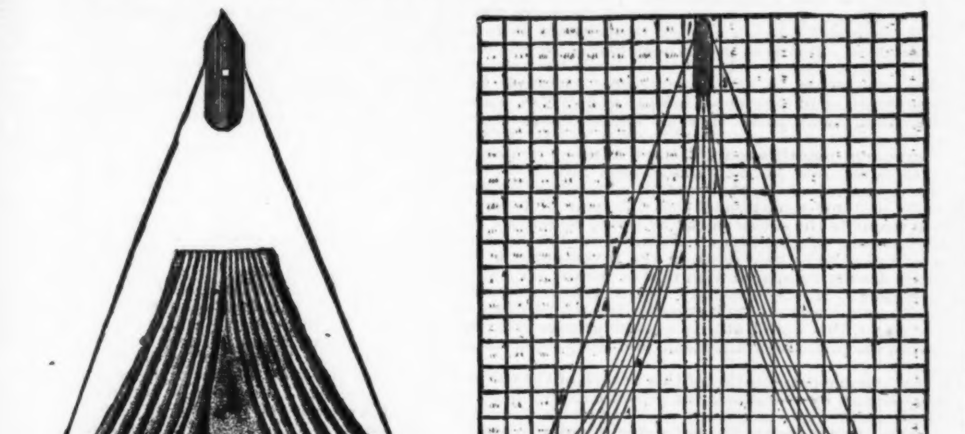

FIG. 5.

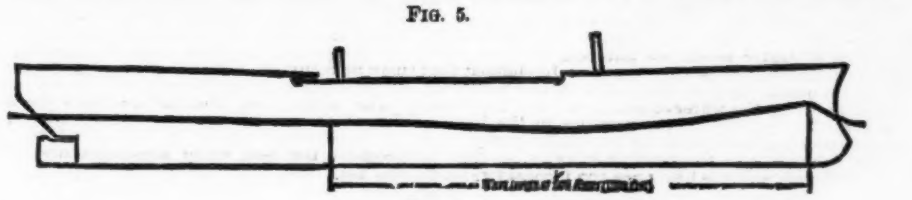

FIG. 6.

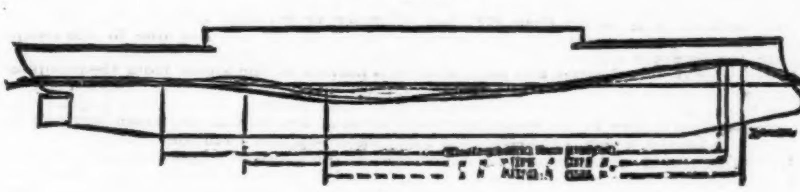

FIG. 7.

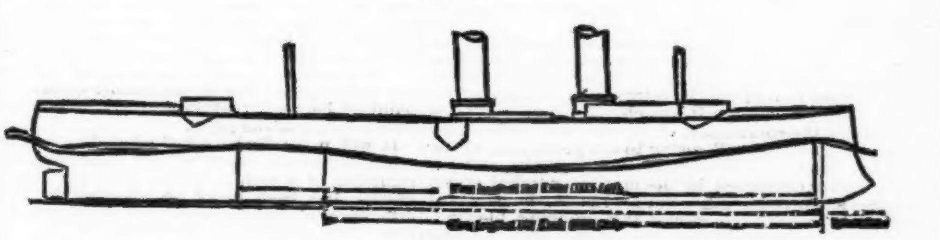

FIG. 8.

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such as to annul, or partially annul, one another's influence in the waves astern of the ship, which is obviously a favorable speed for the particular ship. On the other hand, when the crest of a wave astern due to the bow agreed with the crest of a wave astern due to the "run," they had an unfavorable speed for the particular size and shape of ship. The conclusion of the investigations that Mr. Froude made was that if circumstances permitted, not making the ship too expensive, and if all practical conditions could be fulfilled, without any parallel middle body, it was better to be all entrance and run.

When he was asked to give that lecture, he made it a condition that no practical results were to be expected. But there was one suggestion he ventured to make, founded on the effect of wave making. In the first place, he would give some figures showing the difference between the amounts of wave-making resistance and what was called "skin" resistance, for which he was indebted to Mr. Edmund Froude. In a certain ship of 3,634 tons displacement, going at 13 knots, the skin resistance was 5·8 and the wave resistance 3·2 tons—total resistance 9 tons. At a speed of 14 knots the wave resistance nearly doubled and the skin resistance comparatively little increased—the ship, at 14 knots, had a to look at ships, boats, ducks, and ducklings, moving on water at different speeds, and so, through their own eyes, to study the beautiful subject of ship waves.

THE COMPARATIVE VALUE OF STEAM AND HOT WATER FOR TRANSMITTING HEAT AND POWER.*

THE relative value of steam, water, or other vehicle for the purpose of distributing heat to be used for heating and power purposes curiously involves, in a large degree, the same elements as the transportation of passengers and freight on railroads. With the latter, the relative amount of paying and non-paying load forms one of the most important considerations, while with the former the relative values depend largely upon the percentages of their heat-carrying capacities which can be utilized in practice. In generating steam with fuel, the gases may be reduced in temperature nearly to that of the steam itself, securing fair efficiency, but in melting metals, they must be rejected at a temperature higher than that of the metal, and economy secured by secondary operations to save waste heat. Similarly, the efficiency of the heat-transmitting medium depends upon the amount of heat rejected or unavailable by the conditions of the problem compared with that originally imparted to such medium.

If steam and hot water of 400 degrees temperature be respectively used for some heating purpose, such as cooking, requiring nearly that temperature, the steam will give up its latent heat and be converted into a small quantity of water at the final temperature, while hot water can only give up its sensible heat, represented practically by the difference between its original and final temperature. If the fall of temperature be from 400 to 399 degrees, the water would impart substantially one thermal unit for each pound of water circulated over the surface, while the steam would impart over 800 thermal units for each pound of water condensed. If a difference of two degrees were allowed, the water would impart substantially two thermal units for each pound of water circulated, whereas the heat supplied by the condensation of one pound of steam with same limits of temperature would be but slightly reduced, though the relative quantity of water required to be circulated to equal the results obtained with one pound of steam would be reduced one half. By allowing a still greater reduction of temperature, the water would appear at less disadvantage. For instance, with a difference of temperature of about 11·15 degrees the water would impart 11½ thermal units for each pound of water circulated and the steam 842 thermal units for each pound condensed.* This is doubtless a greater reduction of temperature than could be allowed for cooking, and yet it would require (842·04 ÷ 11·52 =) 72·71 times as much water circulated to do the same work as would be required if steam were used. In this case, then, 72·71 pounds of water would necessarily be heated at the station, pumped to the point where the heat was required, and then be forced back again to the station at a lower pressure and pumped into the boiler to be reheated, for each pound of water evaporated if steam were used as the medium of transmission. The steam would be transmitted by causing a slight difference of pressure from the heating station to the point where it was used, and its surplus pressure would return the water of condensation back to the station, where one pound would require to be pumped in the boiler for each 72·71 pounds by the water system.

As the temperature at which the heat is to be applied is reduced, the preponderance against the water system somewhat diminishes. For instance, if steam at 70 pounds pressure be required to operate engines, it may be obtained by directly expanding down the steam of 235 pounds pressure, which would result in a beneficial superheating of 25·87 thermal units per pound of steam thus expanded. If, however, the steam were supplied from hot water at 400·89 degrees temperature, corresponding to the pressure of 235 pounds, only 10·2 parts in 100 would, on reducing the pressure to 70 pounds, flash into steam at that pressure, so in that case 10·2 pounds of water would necessarily be heated at the central station, transmitted to the point where steam is required, and if high pressure engines were used, 9·1 pounds would necessarily be transmitted back again, and finally 10·1 pounds pumped in the boiler for each pound weight of steam used, instead of the one pound which would be required to be evaporated at the central station in the case of the steam plant.†

For heating purposes, the temperature could, under favorable circumstances, be reduced to 228 degrees in the coils, corresponding to a pressure of five pounds, in which case, without repeating the operations above described, there would require to be circulated from the heating station to the point of supply and back to such station 5·69 pounds of water for each pound of steam utilized at the point of supply, or for the heat which would be imparted at the temperature corresponding to such pressure, for each pound of steam which in a steam system would be evaporated and sent direct from the station.‡

The above statements may be easily verified from the figures given in the foot notes, and the great resistances found in pumping water through pipes at high velocities being well known, there would seem to be no reason why any one should think of using water rather than steam for the purposes above referred to. The subject has, however, been agitated for a number of years. Little plants to show what could be done with water heated to a high temperature have been built from time to time, but apparently did not command the capital necessary to start the business on a large scale.

Another revival has recently been attempted, however, based chiefly on the favorable report of an unusually well informed engineer of experience and acknowledged ability, to whom it is a pleasure to say the writer is personally indebted for many valuable suggestions as to proper courses of study at an earlier period of life. Mr. Isherwood, in forming his opinions, has evidently, however, failed to consider some of the most important elements of the problem, and occasion is thereby made for an abstract discussion on the merits of steam and hot water, so far as possible, without reference to the merits of a particular system and the details of the same.

It has been stated in the public press, quoting from the report, that a cubic foot of water at 400° temperature contains 34⅜ times as much heat as is contained in a cubic foot of steam at the same temperature, and it is

* Paper read at meeting of American Society of Mechanical Engineers, at Washington, meeting June, 1887, by Charles E. Emery, of New York City. Reported in the *Sanitary Engineer*.

* (A) Temperature due to 235 lb. gauge or 200 lb. absolute pressure, 400·89; temperature due to 205 lb. gauge or 200 lb. absolute, 389·74°—difference, 11·15°. Total heat above 32° in the two cases, respectively, 373·75 and 362·17—difference, 11·5 thermal or heat units. Total heat steam of 235 lb. gauge pressure, 1,204·21 heat units. Subtract 362·17 heat units due to final temperature gives 842·04 heat units available from condensation of steam between limits of temperature stated.

† (B) Total heat steam of 70 lb. gauge or 85 absolute pressure, 1,178·34 heat units, which subtracted from 1,204·21 heat units due to 235 lb., foot note (A), shows 25·87 heat units for superheating. Temperature due to 70 lb. gauge 316·08, corresponding to 286·26 heat units above 32°, which subtracted from 373·75 heat units due to 235 lb. (A), leaves 87·49 heat units available for making steam with water, and subtracting same from 1,178·34 heat units, total heat due to 70 lb., gives 892·08 heat units required for steam of 70. lb. Hence, there will be required 892·08 ÷ 87·49 = 10·2 pounds of water circulated per pound of water evaporated into steam of 70 lb. pressure.

‡ (C) Temperature due to 5 lb. 227·96°, equivalent to 196·66 heat units above 32, which latter subtracted from 373·75 heat units in water due to 235 lb. pressure gives 177·09 heat units per pound of water, and subtracted from 1,204·21, total heat due to 235 lb. pressure, gives 1,007·55 heat units available from steam between same limits, so that there will be required (1,204·21 ÷ 177·09 =) 5·694 times as much water circulated as steam.

therefore concluded that "the areas of the pipes will be in this proportion, making their diameters in the proportion of one for the water and ($\sqrt{34\frac{2}{3}}$=) 5·89 for the steam." Also that "the thickness of the material of the pipes for equal strength would have to be about six times greater for the larger steam pipe than for the smaller water pipe, even if both were lap-welded." On the supposition that larger steam pipes would be necessary, comparisons were presented of the "greater bulk," "enormously greater cost," "extra loss of heat by conduction and radiation" due to the larger pipes, with some further remarks about the difficulty of getting rid of the water of condensation in steam pipes, difficulties of management, etc., not at all warranted by the state of the art in relation to steam plants. Evidently the error behind these statements is to be found in the assumption that because a given quantity of water of the temperature assumed contains 34⅔ times as much heat as that of an equal *volume* of steam, therefore the steam pipe must be proportionably larger to that extent. It ignores entirely well known laws of hydraulics, which teach that a fluid of much less density than another will, with the same difference of pressure, flow at a much higher velocity. The weight of a fluid transmitted through pipes with comparatively small distances of pressure at opposite ends, is proportioned to the square root of the fifth power of the diameter of the pipe into the square root of the pressure gradient (represented by the difference of pressure between the two points divided by the length) into the square root of the weight per unit of volume of the fluid; for instance, the weight per cubic foot, called by Weisbach the "heaviness," and herein designated the "specific weight." Therefore, for the same loss of pressure in the same distance and the same size of pipe, the relative weights of water transmitted would vary as the square roots of the specific weights. The weight of a cubic foot of water at 400° is approximately 53 pounds, and a cubic foot of steam at the pressure of 235 pounds due to such temperature is 0·5478 pound. The relative weights of the steam and water are, therefore, as 1 to 96·36. The weights transmitted under like conditions, as above referred to, would therefore be as the square roots of these numbers, or as 1 to 9·816. Therefore, if the steam and water be compared on the basis of use for heating buildings exclusively, which, as has been shown, is most advantageous to the water system, there would, as has been stated, be required a circulation of 5·694 times as many pounds of hot water as of steam, but 9·816 pounds of water would, under like conditions, be circulated to 1 of steam.

The relative capacities of the pipes required to convey the steam and water under like conditions would then be for the steam 1, and for the water the increased weight required, viz., 5·694 divided by the increased weight conveyed, viz., 9·816, or as 1 to 0·5796 or as 1·7253 to 1. But the carrying capacities of the pipes are not as the areas or the squares of the diameters, but, on account of the friction element, as the square root of the fifth power of the diameters, on which basis, under this most favorable condition for the water pipe, the diameter of the steam pipe would require to be but 24·38 per cent. in excess of that of the water pipe. This does not, however, represent the relative cost of the system. For heat taken the same distance, the return pipe of the water system must be as large as the direct pipe, whereas that of the steam system, which has to do but about one sixth of the work, could, on merely theoretical conditions, have a carrying capacity that is much smaller. For practical reasons which, as will be shown hereafter, will have greater force with the water system, this pipe is made somewhat larger, or on the average about one half of the diameter of the steam pipe. On the basis that the costs are proportioned to the lengths and diameters, which is not far from correct when the two pipes are laid together in the same trench, the cost of the steam pipe of 1·2438 diameter should be increased one half to allow for the return pipe, making in the case of the steam system 1·8657 compared with 2 as the cost of the full size double pipes of the water system, which numbers are as 1 to 1·072. That is, even under the most favorable conditions for the water pipes, they would cost at least 7 per cent. more than the steam pipe system, and even this result is obtained by favoring the water system in the calculations, for the reason that the water has to be pumped double the distance that the steam is conveyed, and therefore requires double the difference of the pressure. However, as this pressure is produced with a pump, for simplicity the comparison has been allowed to stand as above.

If the water pipes were designed to furnish power at a distance by generating steam to be used at 70 lb. pressure, it would be necessary, as stated, to circulate 10·2 times as much water as would require to be evaporated for steam used directly, when, on the same basis previously discussed, the water pipes would require to have 3·9 per cent. greater carrying capacity under like conditions than the steam pipe, that is, would require to be of 1·55 per cent. greater diameter, when the cost of both the direct and return water pipes would be 35·4 per cent. greater than that of the steam pipe and its smaller return pipe.

If, however, the water plant were designed to furnish water for cooking purposes, and the temperature were maintained in the stoves at 400° by circulating, as claimed, water of only 400°, there would be required the circulation of an infinite quantity of water to fulfill this condition. If, however, the temperature in the stoves were allowed to fall one degree below that of the water, there would require to be circulated, as first stated, something over 800 times as much water as would be required to be evaporated and conveyed if the work were done by steam. Without stopping to calculate the size of the enormous pipe required on this basis, we may assume, as before, that in practical work a loss of say 11·15° would be permitted. On this basis, as stated, the water required to be circulated would be 72·21 times the weight of steam required to do the work, so the water pipe would necessarily have 7·407 times the carrying capacity of the steam pipe, or 2·228 times the diameter, and the cost of the two systems of piping on the basis above explained would be as 1 for the steam to 2·97 for the water. We thus see that in doing exclusively the work for which these high pressures are principally to be carried—to wit, cooking—instead of the steam pipes requiring to be 46⅓ times the area or 5·8 times the diameter of the water pipe, as claimed, the water pipes must have 7⅓ times the carrying capacity, be of about 2¼ times the diameter, and about 3 times the cost of the steam pipes. The relative cost of the pipes by no means represents the cost of operating the two systems. The water system would always be at a disadvantage in this respect on account of the high cost of pumping.

It should be stated that it is proposed to use steam for power at only 20 lb. pressure, but it is unnecessary to say that this would involve a very extravagant use of steam, and the size of the pipes would only take an intermediate position between those given for heating and power respectively. It may also be claimed that the fall of pressure available to transmit steam is limited, whereas the pressure available by pumping to force the water is comparatively unlimited. This will not sustain investigation. With an initial steam pressure of 80 lb., a loss of pressure of but 10 lb. will give, in a steam pipe twelve inches in diameter and one-half mile long, a velocity of fully 80 ft. per second, so that there will be readily transmitted, through such pipe, nearly 1,700 horse power of 30 lb. of feed water per hour for that entire distance. The most unfavorable conditions for the transmission of steam are when used for cooking where a high temperature is to be maintained. But even in this case, unless the assumption be made that the water will maintain the ovens at 400° with steam at 400° temperature, which, as has been stated, will require an infinite quantity of water circulated, there must be some loss of temperature, and as soon as it is permitted to drop, so that instead of fabulous quantities only 72 times as many pounds of water is required to be circulated as of steam, the loss of temperature of about 11° entails a loss of pressure of 30 lb., and but a portion of this difference of pressure will circulate the steam as fast as would be safe for the permanence of the pipes. With water the velocity would need to be kept down in the inverse proportion of its density compared with that of steam, for a similar reason. If the necessary loss of temperature for cooking be made up by increasing the temperature of the water, this would also, in a much greater ratio, increase the pressure of the steam and still keep it at an advantage.

An average presentation of this branch of the subject may be had by examining the pressure available when the hot water and steam are used to furnish steam for power. In the case of the hot water, in order to evaporate about 10 per cent. of its volume into steam, the reduction in temperature will be that due to a fall in pressure of 165 lb., or from 235 down to 70 lb. In a steam system this entire difference of pressure may be used as the energy which transports the steam to the point where it is used, and as the pumping pressure on the principles above expressed must be double this, the circulating pump would require to work against a pressure of 330 pounds to compete with steam, and 0·2 times as much water must be pumped with the water plant as would be required by the steam plant. Also the water for the water plant must be pumped twice—once at the high pressure of 330 lb. to circulate it in the pipes, and again at 235 pounds to pump it into the boiler—whereas with the steam plant one-tenth of the quantity of water would be pumped, and but once, viz., into the boiler. It may, however, be claimed that the steam plant must be charged with the power required to return the water of condensation. The water is returned in practice by the pressure in the heating systems or by steam operating pumps, or pump traps which exhaust into the heating systems, so that no heat is wasted, and the losses are too inconsiderable to mention in comparison with the handicaps of the water system.

The hot water circulated has been called "superheated water," because it is hotter than 212°, but, of course, water cannot be superheated in the scientific sense that its temperature exceeds that due to its pressure. Steam may be superheated, and must always have as high a temperature as that due to its pressure. Water cannot be superheated, but may, of course, have a pressure greater than is due to its temperature—in other words, be *sub*-heated, which is the condition that the so-called superheated water would be in when maintained at constant pressure the moment it imparted any heat to another object.

Reference must finally be had to one point, which has been made to appear very important on paper. The following quotation may be made:

"The fuel cost of the power developed by the steam engines employed in a hot water system for circulating the superheated water in the hot water pipe, for pumping the used water from the return pipe into the boiler, for driving the blowers, if a mechanical supply of air is needed for the combustion of the coal, and for hoisting coal and its refuse, will, owing to the peculiarity of the system, be not over one-twelfth of the similar cost per horse power developed by the most economical steam engines employed in other work. In fact, the only coal required to work these circulating, pumping, blowing, and hoisting steam engines, is what furnishes the heat actually transformed into work according to the thermo-dynamical theory, and to supply the loss of heat by conduction and radiation from the external surfaces of these engines. The cooled water from the return pipe will be in such excessive quantity compared with the feed water required for generating the steam used in the engines that it will be enormously more than sufficient to condense all the steam worked through the engines, the condensed steam and the water condensing it will be wholly pumped back into the boiler, and there will be no rejected heat, as in the case of other steam engines, which rejected heat averages about eleven-twelfths of the total heat of the vaporization of water. If the cost of the indicated horse power in the best engines be taken at about 2¾ pounds of ordinary coal per hour, that cost, with the engines of a hot water system, will be only one-tenth of a lb. of coal per hour. The steam taken from the boilers at a temperature of 400° F. (pressure 250 lb. per square inch above zero) for working the engines will be condensed by the water of the return pipe at the temperature of say 160° F., and both the water of condensation and the condensing water will be pumped into the boiler, so that the total quantity of water in the boiler and in the hot water pipe and in the return water pipe will always remain constant."

With all the hot water used for power purposes rejected at a temperature of 316° and that for cooking at 390° or upward, how is the very large quantity of heat still remaining in the water to be reduced to the temperature of 160°, as stated in the above extract? It may be said it will be used for heating water, boiling articles of food, heating buildings, and such like uses. But what can be done with it in summer when there is no heating to do? But even in winter, or at any other time, in fact, how is the surplus heat in the hot water from cooking and power apparatus to be exactly that required for some other culinary operation or for heating some particular building? The slightest calculation will show that the surplus heat will be so great that it cannot in practice be reduced to the temperature stated. The low temperature of the return water could only be secured in individual instances in buildings provided with specially large heating coils arranged to receive the water as it was about to escape to the street. Houses and public buildings already provided with heating apparatus would necessarily have connections made to the apparatus in place, and the heat would be rejected at the temperature of the steam used for heating, say at the temperature due to 5 lb., as has been provided for in the previous calculation. In no case, as has been intimated, could it be assured that the surplus heat from the cooking apparatus would not exceed that required for other culinary operations and heating the house. In seasons when no heat was required, the only economical way to dispose of the hot water at 390° rejected from the cooking apparatus would be to pump it back to the station at that temperature and at the temperature due thereto. The result would only be worse were it allowed to expand down to atmospheric pressure, for then a large portion would fly into steam, and the return pipes be filled with a mixture of steam and water. If the hot water were used to generate steam for power the surplus heat would be so great that it would be impracticable to dispose of it in the same or adjacent buildings even during the heating season. Few factories can use all the exhaust steam from their engines, whereas with the water system there would be about five times as much heat in the rejected water as would be used in the engine. If part of the latter be used for heating, the heat in the exhaust steam must be absolutely wasted. In fact, at all times a very large quantity of hot water must be rejected at the temperature of 316° due to the pressure, and, as in the case of cooking, the only economical way would be to return it to the station at a pressure of 70 lb. If it were permitted to expand down to the pressure of the atmosphere, there would be 2·89 cubic feet of steam per pound of water circulated, or 29·4 cubic feet of steam at atmospheric pressure in the returns for each pound of water evaporated into steam for use in the engines, and the volume of steam in the return pipes would be about sixty times as large as the water contained in the same. Of course, in a small plant for exhibition purposes, radiators may be arranged to keep down the temperature rejected from cooking and power systems, but a slight study of the problem will, as above indicated, show that the demands for different purposes cannot be adjusted, even in winter, so as to prevent the rejection of a great deal of heat, and that in summer the heat in the water can practically only be utilized through a small range of the higher temperatures, and much the greater part of the heat must be rejected, though it may be returned to the station at great cost and be saved if practical means are found for the purpose.

The writer has thus far discussed the subject in the abstract without comparison with other work. At this point it may be of interest to state that precisely the feed water apparatus described above has been used from the first in the plant of the New York Steam Company, designed by the writer, and that we are barely able to condense the steam which comes back in the returns *when half the feed water is supplied directly from the Croton mains* to make up for the loss due to the escape steam from high pressure engines supplied on the lines. At times a portion of the steam from the pumping engines can also be condensed in the tank, but at others a portion of this escapes. It is utterly hopeless to do better or even as well with a very much larger proportion of hot water supplied from the returns.

If the present proposed system, to return the water at high pressure, be changed, then, without helping the feed water question, all the old complications of the former developments of the system will be necessary in every house, and under some circumstances boilers would necessarily be used on the premises arranged to be heated by hot water instead of fuel. On the other hand, if steam be used, merely the full range of temperature is available for *every* operation, and the heat rejected due to the smaller quantity of water required be readily returned to the station by the surplus pressure in the pipes.

It will naturally be asked what the probable cost of pumping the hot water will be. This requires the assumption of a certain set of conditions. Previous discussion has been based on allowing the hot water a difference of pressure at the two ends of the line of twice that allowed to the steam between the station and the point of use. On this basis, with a comparatively low pumping pressure, say a difference of twenty pounds between the extremes of the line, the net power required for pumping would be somewhat more than one per cent. for each volume of water pumped compared with that required to be pumped in the boiler for a steam system. Reckoning the efficiency of steam pumps at 50 per cent. on the basis of one horse power for the heat required to evaporate 30 pounds of water from 70 pounds pressure per horse power, there would be required for circulating water for heating fully 11·4 per cent. of the power transmitted through the pipes; for power there would be required fully 20·4 per cent., and for cooking fully 145·4 per cent. Higher pumping pressures would of course entail higher losses. For the steam plant, on the contrary, there would be required on the same basis for pumping the water in the boiler, a little less than two per cent. of the power transmitted, and this cost would be independent of the loss of pressure in transmission. The water in the returns would be forced back, as has been stated, by surplus pressure. It will be seen therefore that the water plant will not only be more expensive to construct originally, as well as more difficult to operate, but that the actual cost of the operation would be greater in the proportions stated, independent of many other considerations which cannot here be discussed, which would make the cost still greater on account of the indirect method of doing the work.

The resistance to explosion of the steam and of the

water pipes could be made the same originally by increasing the thickness of the water pipes proportionally to their increased diameters; but if high capacities were attempted by pumping water at very high velocities, the pipes would be rapidly scoured out so as in time to become dangerously thin. In case of a break in the steam pipe, the steam dissipates at once and is not dangerous. The writer has known a case where, through carelessness of workmen, a man was struck full in the body at a distance of only a few feet by a jet of steam two inches in diameter issuing from a pipe at eighty pounds pressure, but no injury to his person whatever resulted. Evidently, however, a single quart of hot water, projected in the same way, would have caused fearful scalds, and anything like the same quantity of water as of steam would have caused a lingering death. Hot water is also very destructive when the pressure is suddenly released, and the flying particles would scald persons and do other injuries, even when projected long distances.

It is interesting to see all the operations of cooking performed by hot water of high temperature, but evidently every one of these operations could be performed equally well by steam with the pressure due to such temperature, and all the operations would be much more simple and economical. In other words, the advantages due simply to high pressure are claimed for hot water. It may be said that the hot water at the high temperature ought to be compared with steam at the pressures ordinarily carried, but the steam can be supplied at the high pressure much more readily than the water. There is, however, a separate question as to the relative advantage of transmitting steam at the high pressure of 235 pounds referred to above compared with a transmission at a pressure of 80 or 90 pounds, corresponding to that ordinarily used in practice. Evidently, the lower pressure will supply all the steam which is required for heat and power purposes quite as well as if generated at the very high pressure. The only possible object in increasing the pressure would be to do some kinds of cooking which cannot be done with the lower pressure, and it may be claimed to save something in the size of pipes. So far as the latter is concerned, the increased thickness must also be taken into consideration. The culinary operations which require the greatest amount of heat are the heating of water and the boiling of meat and vegetables. This can be done with perfect satisfaction with a steam pressure but little above the atmosphere, say at the ordinary heating pressure of 5 pounds or under. Meat may be roasted and browned satisfactorily if put in steam-jacketed vessels directly on the metal with a steam pressure of 40 pounds. This is done every day in many saloons. Of course, steaks and chops can be cooked in the same way if desired, though without the aroma of slightly scorched meat as in broiling. Cake and bread can be cooked, but not browned, with a steam pressure of 80 pounds. The higher pressure of 235 pounds is only required for such operations as broiling meat and for the baking and satisfactory browning of bread and cake. But little bread is baked in private houses, and that required may be sent either to the baker's or be done in the house by customary methods on a particular day of the week. The other operations stated as requiring a high temperature can readily be performed at very slight expenses with gas stoves. When the comparatively small income to be derived from this particular work is considered in connection with the enormous cost required to do such work, particularly with hot water and also to some extent with steam, it appears to the writer that it will not pay to go to the extra expense and risk necessary to carry steam or the more expensive hot water at such high pressures for this purpose alone, and it is hoped that this presentation will enable others who are required to assume responsibilities in this direction to judge for themselves what limit, everything considered, is the best method to adopt.

LARGE AND SMALL LOCOMOTIVES.

At the Manchester exhibition, Messrs. Beyer, Peacock & Co., Gorton Foundry, Manchester, exhibit a fine express passenger locomotive and tender, of which we give an illustration. This engine has quite an imposing appearance, and is a highly creditable example of locomotive engineering. It is one of a number made for the Dutch State Railway, to run the mail trains between Flushing and Germany. We give below a list of the leading particulars:

	Ft.	In.
Gauge	4	8½
Cylinders (inside):		
Diameter	1	6
Stroke	2	2
Wheels (six):		
Diameter of leading wheels	4	0
Diameter of driving wheels, coupled,	7	0
Diameter of trailing wheels, coupled,	7	0
Boiler:		
Length	10	9
Diameter	4	2⅛
Fire box (copper):		
Length	6	9
Width	3	5¾
Height at front	5	3
Height at back	4	0

Number of tubes 1¾ in. diam., 242.

Heating surface:

Tubes	1,221·9 sq. ft.
Fire box	102·0 "
Total	1,323·9 "

Fire grate area, 23·4 sq. ft.

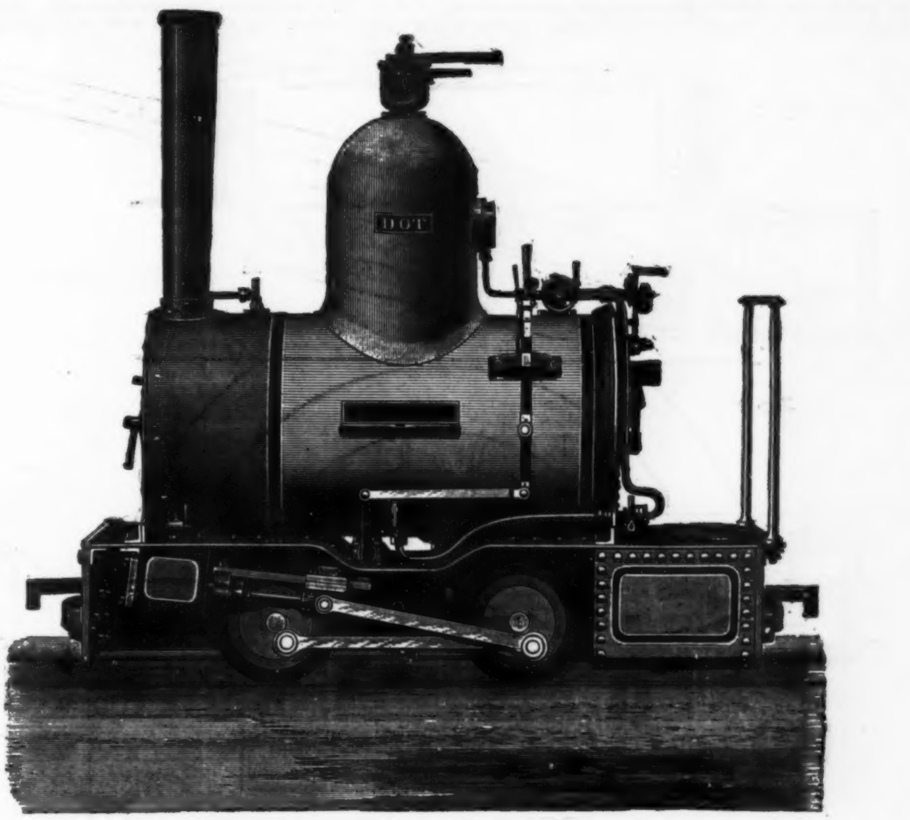
Tender, upon six wheels, each 4 ft. diam.

Water tank to contain 2,400 gals.

Fuel space, 142 cub. ft.

	Loaded. t.	c.	q.	Empty. t.	c.	q.
Weight of engine	39	0	1	36	2	3
Weight of tender	27	10	2	12	1	1
Total	66	10	3	48	4	0

There is also shown by Messrs. Beyer, Peacock & Co., at the end of the large locomotive, a small engine of a type designed and built by the firm for use in their own works, and also for the works of the Lancashire and Yorkshire Railway Company at Horwich. We also illustrate this engine, which, it will be observed, is named Dot, and below we append a list of the leading particulars:



DOT, A ONE-FOOT SIX-INCH GAUGE LOCOMOTIVE.

	Ft.	In.
Gauge	1	6
Cylinders (outside):		
Diameter	0	5
Stroke	0	6
Wheels:		
Number of wheels, all coupled, 4.		
Diameter	1	4¼
Wheel base	2	9
Boiler:		
Length	4	3
Diameter	2	3
Cylindrical fire box:		
Length	2	3⅜
Diameter	1	5
Tubes:		
Number, 55.		
Length	2	0
Diameter (outside)	0	1⅜

Heating surface:

Tubes	39·5 sq. ft.
Fire box	10·9 "
Total	50·4 "

Grate area, 1·8 sq. ft.

Capacity of tank, about 25 gals.

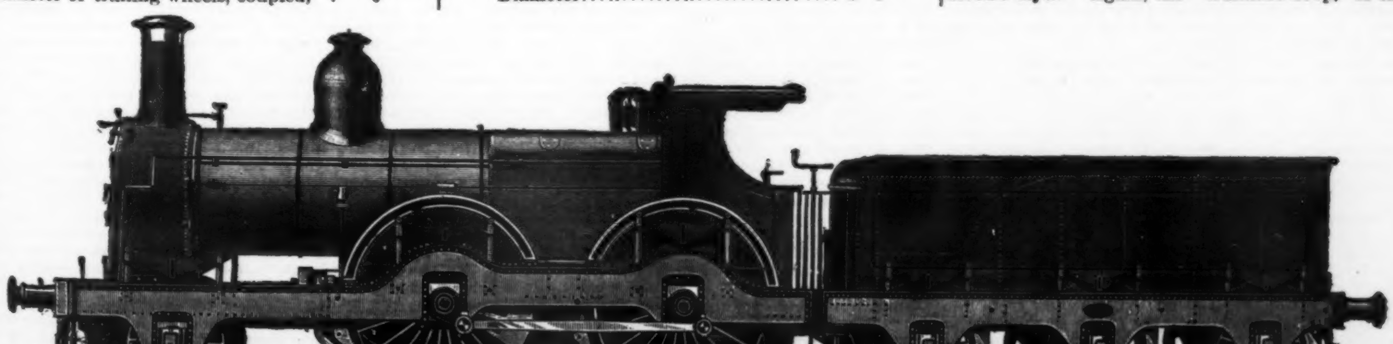
Extreme length of engine, about	7	5¾
Extreme width of engine, about	3	0

Weight in working order, 3 tons 5 cwt.

We may add, says *Industries*, that the contrast between the large and small engines is so striking that some of the visitors have humorously named them Dignity and Impudence.

THE NEW ONE HUNDRED AND TEN TON GUN.

The 110 ton Elswick gun, of which a full size model is shown in the Newcastle exhibition, as represented by Figs. 1 and 2, is the largest gun ever made in England, and, according to *Engineering*, is the most powerful piece of ordnance in the world. This gun has been made for the British government for the armament of first-class ships of war. It is constructed entirely of steel, the "A" or inner tube being in one length. Over the inner tube is shrunk the breech piece, which is surrounded by three layers of comparatively thin hoops of steel. In this manner the whole of the metal assists in bearing the transverse strain. The inner tube extends only to the obturator, or breech block, which engages in the breech piece, the longitudinal strain being partly borne by this piece, assisted by the peculiar distribution of the hoops. A long hoop with stout shoulders forms the rear part of the first layer, and its front shoulder engages the rear shoulder of another long hoop, which forms the front part of the second layer. Again, the "trunnion hoop," so called,



NEW EXPRESS PASSENGER LOCOMOTIVE.

is shrunk on in such a manner as to draw the long hoops of the first and second layers together. Hence there is a direct pull from the trunnion hoop to the shoulder on the breech piece, all parts being solidly bound together against longitudinal strain. There are, in reality, no trunnions, the exterior of the trunnion hoop being formed with rings, B, over which a strong steel band passes, and ties the gun to its carriage, C. To prevent the inner tube moving forward from the breech piece, a ring of bronze alloy is run into a serrated recess at the front of the latter. A similar ring is used to assist friction in keeping the front of the trunnion hoop in place.

In the "obturator," or means of stopping the escape of powder gas, a modification of the De Bange pad, made by Mr. Vavasseur, of the Elswick firm, is under trial. The asbestos pad is retained, but it is covered with a thin sheath of copper, which is forced by compression on discharge of the gun into close contact with the inner tube.

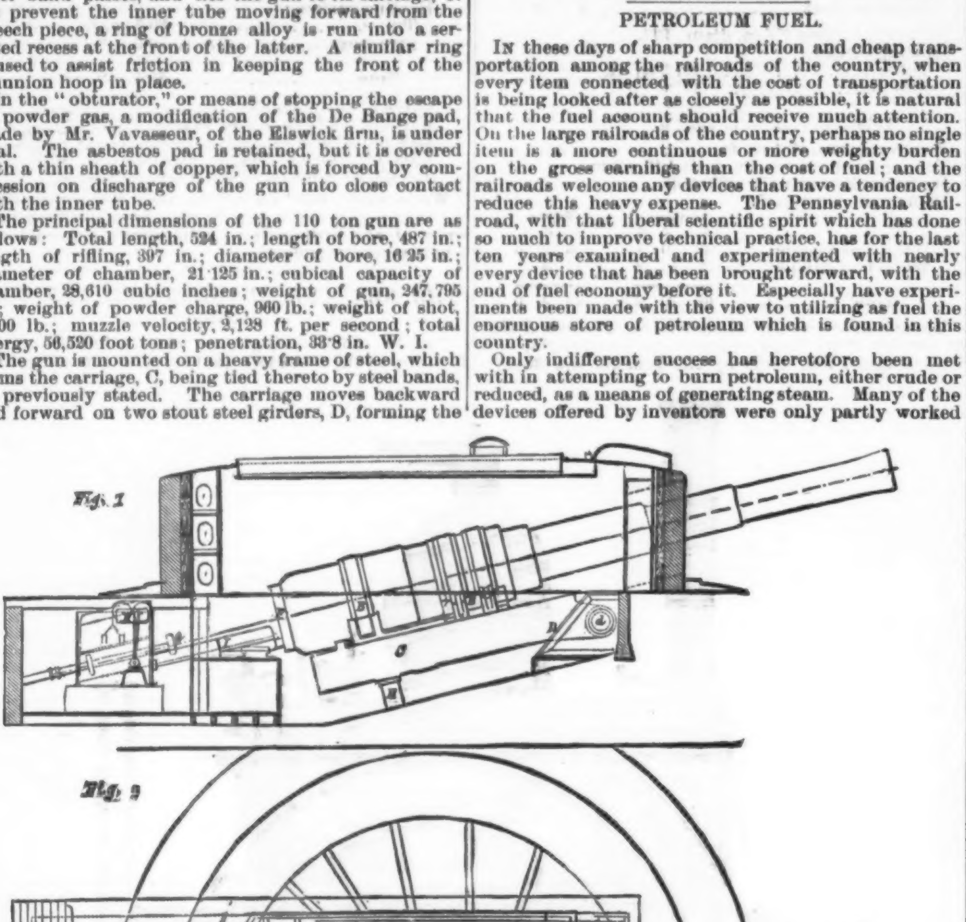
The principal dimensions of the 110 ton gun are as follows: Total length, 524 in.; length of bore, 487 in.; length of rifling, 397 in.; diameter of bore, 16·25 in.; diameter of chamber, 21·125 in.; cubical capacity of chamber, 28,610 cubic inches; weight of gun, 247,795 lb.; weight of powder charge, 960 lb.; weight of shot, 1,800 lb.; muzzle velocity, 2,128 ft. per second; total energy, 56,520 foot tons; penetration, 33·8 in. W. I.

The gun is mounted on a heavy frame of steel, which forms the carriage, C, being tied thereto by steel bands, as previously stated. The carriage moves backward and forward on two stout steel girders, D, forming the slide, the ram of the recoil press passing through the lower part of the carriage, and being fixed thereto. The slide girders are pivoted at the front, *d*, so that the motion of recoil is always parallel to their upper surface. All the operations of working the gun are performed by hydraulic power.

The elevation or depression of the gun and slide is performed by means of hydraulic rams, E, under each slide girder. Pressure is also admitted to one side or other of the recoil cylinder, according as it is desired to run the gun in or out. To turn the gun in a horizontal direction, it is necessary to rotate the platform or turret by means of hydraulic engines, acting on pinions, engaging in circular racks surrounding its base.

By means of hydraulic breech mechanism the breech block, F is unscrewed and moved aside, while the shot and charge are forced into the bore or breech chamber by the hydraulic rammer, G; the breech block is then similarly returned to its normal position. The shot and cartridge (see Figs. 3 and 4) are raised from the magazine by an hydraulic lift, H, so as to deliver the ammunition at the level of the loading tray, I, and between the breech, F, and rammer, G.

The 960 lb. charge for the 110 ton gun is composed of two cartridges of prismatic form, *a* and *b*, 38 in. long by 18 in., as shown at Fig. 4. The first cartridge, *a*, or portion of the charge, is closely filled with powder, but the second portion, *b*, is arranged with a cylindrical space, A, for receiving some quick-firing powder for properly igniting the whole of the charges. The total length of the charge or combined cartridge is 6 ft. 4 in. Slow-burning brown prismatic powder is used for the charge, composed of hexagonal pebbles or cubes of about 1⅛ in. in diameter, and as represented to a reduced scale at Fig. 5 of the engravings. These cartridges are transported from place to place, *e. g.*, from the magazine to ammunition lift, in a water and fire proof metallic case, as shown at Fig. 6. The common steel shell represented at Fig. 3 is 4 ft. 7 in. in height, and weighs 1,607 lb. empty and 1,800 lb. when charged.



THE NEW 110 TON ARMSTRONG GUN, THE MOST POWERFUL CANNON IN THE WORLD.
Powder Charge, 960 lb. Shot, 1,800 lb. Penetration, 33·8 in W. I.

PETROLEUM FUEL.

In these days of sharp competition and cheap transportation among the railroads of the country, when every item connected with the cost of transportation is being looked after as closely as possible, it is natural that the fuel account should receive much attention. On the large railroads of the country, perhaps no single item is a more continuous or more weighty burden on the gross earnings than the cost of fuel; and the railroads welcome any devices that have a tendency to reduce this heavy expense. The Pennsylvania Railroad, with that liberal scientific spirit which has done so much to improve technical practice, has for the last ten years examined and experimented with nearly every device that has been brought forward, with the end of fuel economy before it. Especially have experiments been made with the view to utilizing as fuel the enormous store of petroleum which is found in this country.

Only indifferent success has heretofore been met with in attempting to burn petroleum, either crude or reduced, as a means of generating steam. Many of the devices offered by inventors were only partly worked out, many had inherent defects which made them failures on trial, and it is only recently that a device has come forward which promises to be a success. The history of the devices for getting heat by burning oil is a very curious one. Not a few have attempted to convert the oil into gas and burn the gas. Others have attempted to simply vaporize the oil and burn the oil vapor. Some of them had a separate appliance located on the tank, or elsewhere on the locomotive, to convert the fuel into a condition to burn; while others put their appliances into the fire box, where the heat was so great that the decomposition of the oil resulted in deposited carbon, which clogged up the burners. It remained for Mr. Thomas Urquhart, a Scotchman by birth, and who is at present locomotive superintendent of the Grazi-Tsaritzin Railroad, in Southeastern Russia, to develop the first successful scheme of using petroleum as fuel, at least on locomotives. Avoiding the errors and mistakes of previous inventors, Mr. Urquhart* has devised a scheme which, like all great things, is extremely simple, and at the same time is very successful. His device can be applied to any locomotive boiler or, indeed, to any stationary boiler; of course, with modifications, which are easily made, to adapt the essential features of the device to the boiler in use, and it seems to work equally well with boilers of almost any construction.

The essential features of Mr. Urquhart's scheme of burning petroleum consist in converting the oil itself into a finely divided state or spray, by means of a jet of steam or compressed air, and then burning this spray in the fire box of the locomotive, in a fire brick furnace constructed inside the fire box. The burner or spray producer, if it may be so called, is essentially two tubes, one inside the other, the inner tube carrying the jet of steam or compressed air, and the outer tube carrying the oil. The oil tube is prolonged some distance beyond the steam tube, to allow the steam and oil to combine, and then the two together are projected from the end of the oil tube into the fire box by the force of the steam. A single burner weighing, perhaps, 40 lb. is sufficient for a locomotive of the largest size. The fire brick furnace inside the fire box is very simple in construction, and may be crudely compared to a bonnet, with the open end of the bonnet toward the injector or spray producer. The object of fire brick is to receive the small particles of oil that escape combustion before they reach the fire brick bonnet, and break them up so that they may be consumed. The bonnet furnishes, also, a combustion chamber for the proper mixing and burning of the oil and air; and serves another very important service, in that the fire brick becomes intensely hot and radiates heat to all parts of the fire box, and at the same time serves to reignite the oil after it has been shut off for a short period from any cause, as stopping at stations.

A representative of the Pennsylvania Railroad visited Mr. Urquhart in Russia last year, and brought home a trial burner and drawings. During his absence the published papers of Mr. Urquhart on the subject became available for use, and this information was turned to account. As the result of these two sources of information, a locomotive was fitted up at the Altoona shops in December last, and has been experimented with more or less since that time. It will be readily understood that the conditions in this country and in Russia are somewhat different. American locomotives are worked much harder, and consequently burn more fuel per hour. Moreover, the construction of locomotives is not alike, and it has taken considerable experiment and modification to adapt Mr. Urquhart's plans to American locomotives.

These modifications apparently have now all been made, and a perfectly successful trial trip from Altoona to Pittsburg and return was made on June 17 and 18. The engine, No. 408, going west, took the mail train, and coming back took the second section of the day express. On the return trip, with a heavy train, the engine made up 25 minutes on schedule time, and in no case did the steam pressure fall below 110 lb. Most of the time it was just on the verge of lifting the safety valve—125 lb. When the pressure did fall to 110 lb., it was after a long pull on the western slope of the mountain, when both injectors were put on to replenish the water supply, which had become a trifle low during the long pull. The amount of oil consumed during the trip east was 3,897½ lb., and during the trip west was 3,634½ lb. In both cases considerably less oil was consumed than was thought to be necessary for the trip.

The working of the device on the locomotive is in every respect charming. One is first struck by the absolute freedom from smoke and cinders. The work of the fireman is limited to the management of a hand wheel, and there is the most perfect relation between the amount of steam consumed and the amount of oil burned. A slight turn of the hand wheel, allowing a little more oil to go into the fire box, produces smoke; a slight turn in the opposite direction relieves the smoke. A movement of the reverse lever one notch, thus causing less steam to go into the cylinders, shows instantly in a little smoke at the smoke stack. This is at once relieved by turning the wheel and allowing less oil to go into the fire box. A movement of the reverse lever in the opposite direction, working the engine a little harder, causes the steam pressure to fall a trifle. The ever-ready wheel and the constant watchfulness of the fireman give more oil, and the steam pressure is regained. Oil burning is absolutely ideal firing. To one riding on the locomotive, the slight rumbling due to the rapid combustion of the oil, and an occasional glance through the peep hole into the white-hot fire box, are the only evidences of fuel consumption. The dirt, dust, smoke, and cinders, and the constant opening and shutting of the fire door, are all absent.

The experience of the Grazi-Tsaritzin Railroad in Russia, which now has 143 locomotives burning petroleum, by the same method as above described, and the experiments already made on the Pennsylvania Railroad, make it safe to assume that the technical part of the problem of oil burning is solved. It is entirely possible to burn petroleum successfully as fuel for steam generation, and experiments have been in progress for some time for its use for a number of other purposes. In view of this possible use of petroleum largely as fuel, the question of economy becomes very important. The following simple data, which are the results of careful experiments, and which also are confirmed by the chemical composition of both coal and oil, may be safely trusted. The heat-producing power of a pound of petroleum is as great as the heat producing power of 1¾ lb. of coal. In other words, one pound of petroleum successfully burned will generate as much steam under the same circumstances as would be produced by the burning of 1¾ lb. of coal in locomotive practice, taking into account the cost of handling the fuel and disposing of the ashes; and also taking into account the diminished repairs to the locomotives, especially to the fire boxes, due to oil burning, it is found as the result of a year's trial that a pound of oil is as good as two pounds of coal. In brief, these two ratios may be described by saying that, weight for weight, oil is to coal as 1 to 1¾, when fuel account alone is considered, and oil is to coal as 1 to 2 when all the ascertained economies are considered. The reduced oil, which is preferred for use in steam generation, weighs on the average a trifle over 7·3 lb. per gallon; or supposing a barrel of oil to consist of 42 gallons, and to weigh as above stated, 6½ barrels of oil make a ton almost exactly. The price, therefore, of 6½ barrels of oil is the cost of a ton of fuel oil. This cost per ton being divided by 1¾ gives the equivalent price per ton of coal when fuel account alone is taken into consideration, or divided by two gives the equivalent price of coal per ton, when all the ascertained economies are taken into consideration. A very simple rule to follow is as follows: Multiply the price of oil per barrel by 3·71 and the product will be the equivalent cost per ton of coal when fuel account alone is considered. Again multiply the price per barrel of oil by 3¼, and the product will be the equivalent price per ton of coal, when all

* For engravings and descriptions of Mr. Urquhart's apparatus as applied to locomotives, and for other examples of apparatus for burning petroleum, see Scientific American Supplement, Nos. 63 and 403.

the ascertained economies are taken into consideration. As above stated, these figures are based on a trifle over 7·3 pounds per gallon for oil, and 42 gallons per barrel. If heavier or lighter oil is used, or the quotations are made by the gallon, it is evident that the figures must be varied accordingly, but the above data may fairly safely be trusted in working out the relative economies of oil and coal for fuel.

As to the possibility of any large use of petroleum for fuel, the outlook is not very favorable. The Pennsylvania Railroad alone burns 8,000 tons of coal a day, and if this fuel consumption should be changed at once from coal to oil, it would consume over one-third of the total daily oil production of the United States. This of course makes any very extended use of petroleum as fuel, with present supply, out of the question. On the other hand, to a limited extent there is unquestionably a field for petroleum as fuel. In places where the nuisance of smoke and cinders is very great, or where the item of transportation is a large element in the cost of the fuel, or where the handling of fuel, and especially the disposal of the ashes, are important items, there is unquestionably economy possible by the use of fuel oil. The figures given above will enable any one to work out the problem for his own locality. The natural effect on the oil market of burning large quantities of petroleum would be to cause an increase of price, and this will probably be the first result. But it is apparent that, at present prices even, say two or three cents per gallon, the chance for fuel oil is small, leaving out of question the possible supply. There are a few places in the country where oil at present quotations can be used with economy as fuel; but if the oil refiners put up the prices, anticipating a large demand for fuel oil, they will certainly defeat themselves, and make the use of oil as fuel uneconomical compared with coal.

It should be stated here that the use of crude oil for fuel is not recommended, for several reasons. First, crude oil at the same price per gallon is very much less economical than the reduced oil, because of the less weight. Second, the crude oil constantly gives off gases, which it would be almost impossible to hold, and dangers from explosion would result. Third, the crude oil is very much more offensive so far as odor is concerned. Fourth, the relative proportions of carbon and hydrogen in the reduced oil only vary one or two per cent. from these proportions in the crude oil, so that, although crude oil is much more inflammable than the reduced oil, its heat-producing power, pound for pound, is very little, if any, in excess of the reduced oil, and, as above stated, the reduced oil weighs from one to two pounds more per gallon than the crude oil.

Should any considerable demand spring up for fuel oil, it is entirely possible that changes will have to be made in the present methods of refining petroleum, the distillation being managed so as to take out from the crude oil the products easiest removed and most valuable to the refiner, and leaving the residues for fuel. If the figures given above are correct, it would seem that the future of the petroleum industry in the United States is largely in the hands of the refiners. If they manage their refining in such a way as to turn a portion of the product into fuel, at a price at which this fuel can compete with coal, the reaction on the other products of the petroleum industry will unquestionably be great. This is especially true of the paraffine industry and its allied products. A consumption of 10,000 barrels per day of reduced oil would unquestionably raise the price of the paraffine products within the first month, and this new outlet for what has up to the present time been somewhat of a burden cannot but be welcomed by the petroleum industry.

It only remains to say that the Pennsylvania Railroad will probably continue its experiments, and gradually bring the use of oil burning into practice, wherever it will result in economies. From the figures given above, however, it is quite evident that new fields must be discovered and the production largely increased before it will be possible to do more than perhaps run some few high-priced passenger trains, or possibly shifting engines in towns, and in some localities stationary boilers, by means of oil.—*Railroad Gazette.*

"RAPID" OPEN HEARTH STEEL PLANT.

THE plant of Mr. B. H. Thwaite, C.E., of Liverpool, and Mr. A. Stewart, M.E., of Bradford, which we illustrate, is designed to effect the manufacture of steel by a combined pneumatic and open hearth process, so as to obtain an approach to the rapidity of the former with the advantages of control possessed by the latter, and at a low cost for plant. The open hearth process, whether effected by the Landore, the pig and ore, pig and scrap, and by an oxidizing nature of combustion, gives equally reliable and uniform results, and permits steel of the mildest quality to be obtained, and, although the pneumatic process has the advantage of greater rapidity, the former or open hearth process is gradually coming to the front. In the Thwaite-Stewart process the action of conversion is divided into three operations: (1) The initial melting by Stewart's "rapid" cupola, and the collection of the charge in a receiver. (2) The passage of the metal through a cylindrical converter, in which it is submitted to the pneumatic conversion action, by which its impurities are oxidized and reduced to as low a limit as will permit a complete control over the final character of the metal in the bath of the open hearth and finishing process. The blast is turned off when three-quarters of the charge has passed through converter. The remaining metal washes the slag into open hearth furnace. (3) Finishing the conversion either by the use of an oxidizing flame, the addition of solid oxygen in the form of iron ore, or by dilution obtained by the addition of low carbon scrap. The usual addition of ferro can be made prior to tapping.

The casting ladle arrangement is designed so as to be rapidly revolved after the metal is charged therein in order to produce a metal of more uniform constitution. The method of casting the ingot is also novel, and is designed to produce thoroughly sound ingots free from gas cells or pipings.

Both arrangements are the invention of Mr. Thwaite. The system of combustion is on the forced blast or plenum air supply principle. The Roots blower supplying the air blast for the cupola also supplies the air blast for the pneumatic process and for the combustion of gas in the open hearth furnace as well. By this plenum air supply system the combustion is under absolute control, and can be intensified to the fullest degree. It further renders an expensive chimney and high chimney temperature unnecessary, and increases, when required, the intensity of the oxidizing action of combustion. Any oxide of iron or slag blown over, along with the gases, is collected in the depositing chamber of the recuperative or hot air stoves. The reversing arrangements of the flow of air and gas are exceedingly simple, and one action serves to actuate both valves. The gaseous fuel is supplied from one of Thwaite's twin or duplex gas producers; the former type is very simple, and gives satisfaction to users. The duplex producer generates gas by a new arrangement, by which a gas resembling water gas is produced. Its composition is 4 H+N+4 CO.

Referring to our illustrations, Fig. 1 is a longitudinal section through a cylindrical converter open hearth furnace and connecting mains, while Fig. 2 shows the general arrangement of the Thwaite-Stewart plant in plan. Fig. 3 is a cross section through a cylindrical converter and recuperative or hot blast stoves. The "rapid" cupola, A, is fed with pig by means of a fuel and pig hoist; the melted pig is collected in the receiver, B. The metal is tapped by removing the plug from the tap hole of receiver, C, into a rocking runner, from which it falls into the lip opening, D, of the cylindrical converter, and which can be closed by a solid and heavy refractory plug, E. The charge gravitates through the invert channel of the converter, F, and is subjected to jets of air from the tuyeres, G. The metal flows into the open hearth furnace, H, from which it can be tapped by the tapping spout, I, into the ladle, J. The gas from the Thwaite gas producer enters the furnace by means of the converging tuyeres, K and L, at each end of the furnace; the air tuyeres, U and V, also converge on to the gas tuyeres, and both gas and air are thoroughly mixed.

The air supply is obtained from a Roots blower by means of a pipe, M, and it flows through the valve, N, and also through the refractory lined connecting flues, O, into the oxide depositing chamber, P, of the recuperator vessel, Q, to the lower end of which it descends, and then flows under a division wall into the nest of checker brickwork, Q, through which it flows, becoming heated by its abstraction of the heat transmitted to the brickwork at a prior period by the products of combustion and conversion. The air passes from the recuperator vessel into connecting mains through the reversing valve, S, and flowing into the flue, T, passes right and left to the air tuyeres, U and V, of the open hearth furnace. The products of combustion and conversion pass in different directions through a duplicate set of mains and a recuperator vessel, and finally escape by the chimney, 3. The air for conversion purposes is delivered to a distributing main, 4, to side delivery pipes, 5, and finally to the tuyeres, G. Each tuyere is provided with a screw plug valve. The plant shown in our illustration is for producing 100 tons of mild steel ingots per week, and is intended for Chili. The plant is being introduced by Messrs. Thwaite Bros., of the Vulcan Iron Works, Bradford, Yorkshire, and will, we think, prove of great value to steel users and to many in the steel trade.—*Iron.*

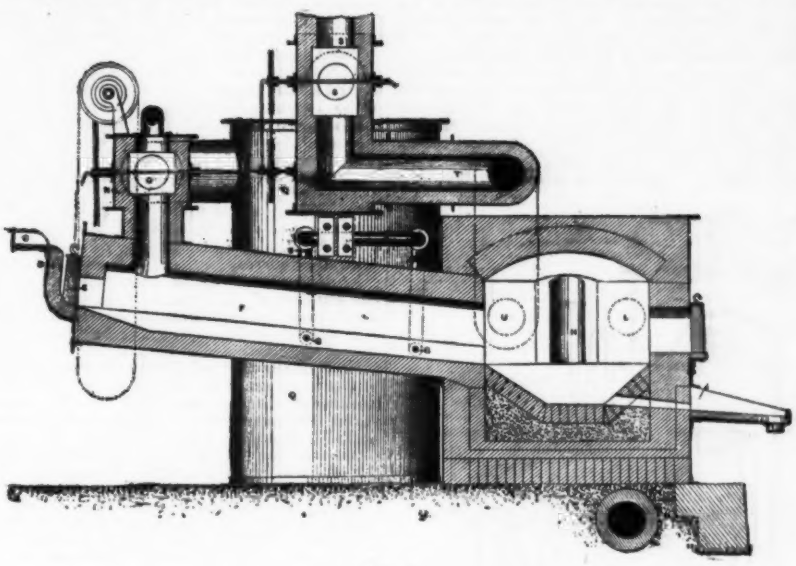


FIG. 1.

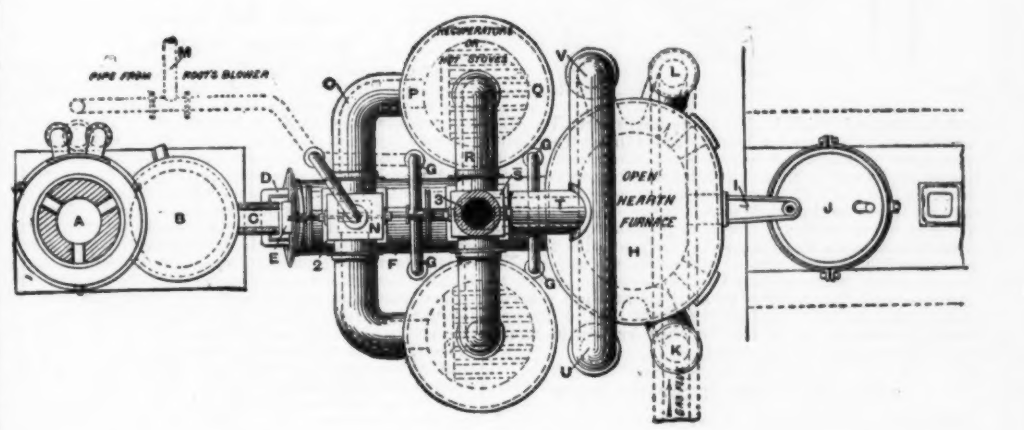


FIG. 2.

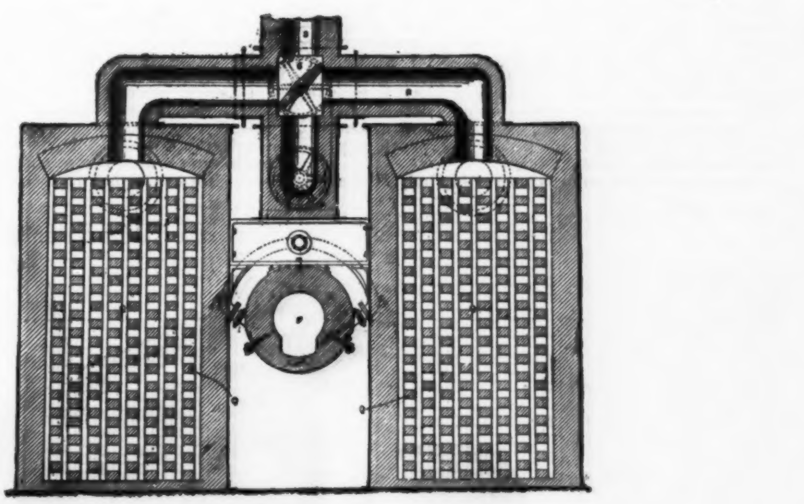
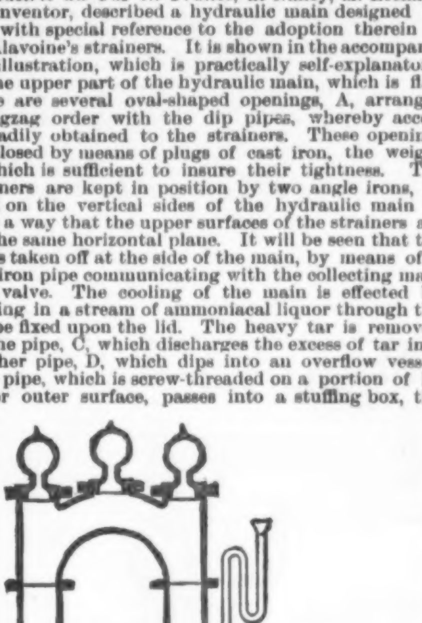


FIG. 3.

"RAPID" OPEN HEARTH STEEL PLANT.

A NEW ARRANGEMENT OF HYDRAULIC MAIN.

At the recent meeting of the *Societe Technique de l'Industrie du Gaz en France*, at Nancy, M. Leclaire, the inventor, described a hydraulic main designed by him with special reference to the adoption therein of M. Alavoine's strainers. It is shown in the accompanying illustration, which is practically self-explanatory. In the upper part of the hydraulic main, which is flat, there are several oval-shaped openings, A, arranged in zigzag order with the dip pipes, whereby access is readily obtained to the strainers. These openings are closed by means of plugs of cast iron, the weight of which is sufficient to insure their tightness. The strainers are kept in position by two angle irons, B, fixed on the vertical sides of the hydraulic main in such a way that the upper surfaces of the strainers are on the same horizontal plane. It will be seen that the gas is taken off at the side of the main, by means of a cast iron pipe communicating with the collecting main by a valve. The cooling of the main is effected by sending in a stream of ammoniacal liquor through the S pipe fixed upon the lid. The heavy tar is removed by the pipe, C, which discharges the excess of tar into another pipe, D, which dips into an overflow vessel. This pipe, which is screw-threaded on a portion of its upper outer surface, passes into a stuffing box, the



cast iron cap of which is also threaded internally. By turning the pipe, the level of the liquor in the hydraulic main may be raised or lowered—an operation which can be performed without the least inconvenience while work is going on. It is claimed for this arrangement that by it the minimum of dip is insured in all cases; while at the same time there is no possibility of the gas passing back into the ascension pipes at the time of charging the retorts. Four hydraulic mains on this system have been installed in the new gas works at Dijon on a similar number of settings of nine retorts, placed back to back; and at the date of the French society's meeting two of the benches had been working satisfactorily for three months.

APPARATUS FOR TESTING OILS.

Messrs. Rieter & Co., of Winterthur, Switzerland, have devised a new machine for testing lubricating oils, which we illustrate herewith. It consists of a solid cast iron frame upon which there is a horizontal shaft provided with a pair of driving pulleys, fast and loose, actuated by a belt. This shaft, through a bevel wheel keyed to it, actuates a vertical shaft by gearing with a pinion that the latter carries. The velocity of the vertical shaft is thus subordinated to the number of the teeth of the bevel wheel. This same shaft is provided at the upper extremity with a hollow friction cone, upon the inside of which is deposited a small quantity of the oil to be tested, and which has previously been measured with a special gauge.

Into this hollow cone is accurately adjusted a solid one, whose travel is limited by a strip of leather affixed on the one hand to the solid cone and on the other to a spiral spring which gradually expands until it balances the moments of resistance and power. At this instant, the extension of the spring is proportional to the friction of the cones.

As the movable extremity of the spiral spring undergoes a traction from the strip of leather, it moves a traveler that slides vertically along a rod of square section. With this traveler is connected a lever, one end of which is provided with a style, which from time to time marks a dot upon a sheet of paper carried by a cylinder. The distance between the different dots, as compared with a datum line corresponding to the nontension of the spiral spring, indicates the value of the coefficient of friction between the two cones. This datum line is marked at the base of the cylinder by a stationary pencil, which is regulated at the beginning of the experiment so as to be in accordance with the height of the movable end of the spring at rest.

The automatic dotting is done as follows. The square rod of the traveler revolves upon a pivot and is connected at the base with a bent lever which is acted upon by a cam mounted upon a small shaft actuated by the friction cones through the intermedium of a combination of endless screws and wheels. This cam shaft is so arranged as to keep the style away from the cylinder during 500 revolutions of the vertical shaft; then, at the five hundredth revolution, the point, suddenly freed, makes a dot upon the paper wound round the cylinder, the velocity of which is so calculated that the dots shall be $\frac{1}{10}$ mm. apart, so as to form a curve whose ordinates correspond to the friction between the conical surfaces, and whose abscisses are proportional to the number of revolutions made by the friction cone shaft from the beginning of the experiment.

A wooden scale accompanying the apparatus carries five divisions, one of which gives the number of revolutions of the vertical shaft corresponding to the length of the diagram with respect to the abscisses, and consequently during the time of the experiment. It shows the duration of the lubricating power of the oil tested. The four other divisions take account of the ordinates for four different charges on the solid cone. They are calculated to give, through a simple reading, the coefficient of friction for each of the charges.

When the friction exceeds certain limits, as a consequence of the disappearance of the lubricating power of the oil, a peculiar mechanical arrangement automatically arrests the apparatus, thus securing to it a long duration.—*Le Genie Civil.*

APPARATUS FOR TESTING LUBRICATING OIL.

SAND FOR GLASS.

By George Wardman.

The manufacture of sand is an important industry, which has Pittsburg for its headquarters, although the sand is not made within the limits of the city. There is a considerable traffic in Monongahela sand, which is scooped up from the bed of the river, to be used for common building purposes; but the manufacture of sand is quite another affair, and the product goes into quite a different commodity, which is glass.

Practically, glass is almost pure sand, other substances used in its manufacture for fluxing being consumed while the sand is transformed to a greater or less degree of transparency. The sand used in glass making is almost pure silica, so nearly pure that there is less than one per cent. of iron, magnesia, and aluminum to ninety-nine + per cent. of the other. And of this sand, which is quarried out of the hills and ground down to varying degrees of fineness and washed to varying degrees of whiteness, eight hundred tons are manufactured daily, four hundred tons being consumed in and about Pittsburg, and four hundred tons going into Eastern Ohio and West Virginia to Wheeling, Bellaire, Columbus, and all points within a circuit of one hundred and fifty miles from Pittsburg.

In selecting, a darkish sand is found, containing more foreign substances than the ninety-nine per cent. silica, which inferior grade goes into green or "black" bottles, and a still darker and baser earth, which is used for sanding fire-brick moulds; another and finer dark grade, which is used by crucible steel manufacturers; and still another quality, the whitest and grittiest, which becomes "flint," or what might be called absolutely transparent glass. An inferior quality of white sand is used for prescription bottles, but the very best is for the higher grade of flint ware.

Looking through the flat surface of window glass, whether plate or blown, it appears colorless; but if the sight is directed through the edge, it will disclose a sea green tinge. Flint glass proper is not so. It is absolutely colorless, except when cut into faces or prisms, when it reveals the colors of the spectrum.

The cost of a ton of sand to glass manufacturers of Western Pennsylvania, Eastern Ohio, or West Virginia is, of course, dependent on the distance it is hauled from the quarry; but taking the eight hundred tons daily manufactured and consumed, it will not average above $2.25 per ton, damp. Dried sand will average $2.50 per ton. Of course, it costs a little less than those figures in Pittsburg, and a little more in Bellaire, Ohio; but even at this last named place the cost of the sand which goes into the manufacture of a box of common window glass, containing the regulation fifty square feet of surface, is about five cents; that is, the box of glass consists merely of five cents' worth of silica, transmuted to a state of transparency.

The sand used in the glass industry in Western Pennsylvania, Eastern Ohio, and West Virginia comes from three quarries—one on the Pennsylvania Railroad, overlooking the Juniata; one on the Baltimore and Ohio Railroad, near Connellsville; and one on the Pittsburg, McKeesport, and Youghiogheny Railway, twenty-five miles south of Pittsburg. It is quarried out like building stone, passed through a quartz crusher, further reduced under immense iron wheels, and finally ground and washed in an endless screw. The washing releases some of the foreign substances, but streaks of iron which are sometimes found running through the stone are knocked off to undergo the milling process for the inferior quality of sand, some of which goes into mortar for specially fine and durable wall building. The railroads use large quantities of it in the construction of retaining walls for embankments. And so all grades of the sand are utilized.—*Popular Science Monthly.*

[From the American Journal of Science, 1887.]

ON RED AND PURPLE CHLORIDE, BROMIDE, AND IODIDE OF SILVER; ON HELIOCHROMY AND ON THE LATENT PHOTOGRAPHIC IMAGE.

By M. Carey Lea, Philadelphia.

In this series of papers it will be my object to show:

(1.) That chlorine, bromine, and iodine are capable of forming compounds with silver, exhibiting varied and beautiful coloration, peach-blossom, rose, purple, and black; that these compounds (except under the influence of light) possess great stability; that they may be obtained by purely chemical means and in the entire absence of light.

(2.) That of these substances the red chloride shows a tendency to the reproduction of colors. It seems not improbable that the material of the infinitesimally thin films obtained by Becquerel, Niepce De St. Victor, Poitevin, and others in their experiments on heliochromy may be the red chloride.

(3.) That these substances, formed by purely chemical means, constitute the actual material of the latent or invisible photographic image, which material may now be obtained in the laboratory without the aid of light and in any desired quantity. They also form part of the visible product resulting from the action of light on the silver haloids.

For more than a generation past, the nature of the latent photographic image, that which forms the basis of development, has been in dispute. Two theories have been maintained. According to the one, the first effect produced by light is simply a physical change, predisposing the elements of the silver haloid to dissociation, so that when a reducing agent is applied, the molecules so affected yield more quickly to its influence. According to the other theory, the invisible image is formed of a subsalt (subchloride, etc.). Observations which I published many years ago led me strongly to the first mentioned of these theories. But of late years, results have been obtained not easily reconcilable with it. On the other hand, the theory that the latent image is formed of subsalt is opposed to striking facts. Silver subchloride, for example, is an unstable substance, quickly destroyed by dilute nitric acid. But I have formed a latent image on silver chloride, and after exposing it for five minutes to the action of strong nitric acid (sp. gr. 1·36), have developed the image without difficulty. The same with silver bromide. Evidently these images, which so strongly resisted the action of undiluted acid, could not be formed of simple subchloride and subbromide of silver—substances quickly destroyed by it.

In the desire to find a satisfactory explanation of the nature of the image based on adequate chemical proof, I have devoted nearly three years of laboratory work to this and to closely allied subjects. I am led to the conclusion that neither of the older views is correct. A truer theory seems to be deducible from the result of some experiments which I published in 1885, to the effect that the silver haloids were capable of uniting with certain other substances, much in the same way that alumina forms lakes. When a silver haloid was precipitated in the presence of certain coloring matters they combined with it, and though soluble in water, they could not be subsequently washed out. They had formed a somewhat stable compound, although the proportion of coloring matter was very small in comparison with the haloid—evidently much too small to represent a stoichiometrical composition.

Now I find that a silver haloid may in the same way unite with a certain proportion of its own subsalt, which by this union quite loses its characteristic instability and forms a compound of great permanence.

Another explanation is possible; the subsalt may combine with the normal salt, not in the manner above described, but in stoichiometrical proportion, and this compound may be diffused through ordinary silver haloid. I have not been able to find any reaction decisive between these explanations,* but the general behavior of the substance seems rather to indicate the first-named explanation as the true one. When the red chloride, for example, has been boiled with dilute nitric acid for a few moments to eliminate any uncombined subchloride, the proportion of subchloride left

* Silver chloride may be dissolved out by hot solutions of sodium or ammonium chloride, but the subchloride is at the same time decomposed. See beyond under head of "Reactions."

has never exceeded 8 or 9 per cent. in over thirty specimens analyzed. If we took this to represent a compound in equivalent proportions, we should have to suppose the union of at least twenty equivalents of AgCl with one of Ag_2Cl, which is improbable. If we suppose that these colored substances containing from less than one-half per cent. up to eight or nine per cent. of Ag_2Cl consist of a compound of one equivalent of subchloride united to a small number of equivalents of normal chloride, mixed mechanically with a large quantity of normal chloride, then it would be improbable that specimens could not be obtained containing a larger proportion of this compound and consequently of Ag_2Cl, but, as already said, specimens containing more than 9 per cent. after thorough treatment with nitric acid to remove the uncombined subchloride I have never obtained. Generally, the amount is less.

Even when silver chloride, bromide, or iodide contains as little as one-half of one per cent. of subsalt combined, its properties are greatly changed. It has a strong coloration, and its behavior to light is altered. Even a much less quantity, one inappreciable to analysis, is capable of affecting both the color and the behavior to light.

It is one of these latter forms of this substance that constitutes the actual material of the latent photographic image. Adequate proof of this will be given in the second part of this paper.

RED SILVER CHLORIDE.

Of the three haloids, the chlorine salt is the most interesting, because of its relations to heliochromy. It is also the most stable of the three compounds, and exhibits perhaps a finer variety of coloration, though the bromide and iodide are also obtainable of very beautiful tints. The chloride shows all the warm shades from white to black through the following gradations: white, pale flesh color, pale pink, rose color, copper color, red purple, dark chocolate, black.

These compounds are obtained in an endless variety of ways. By chlorizing metallic silver; by acting on normal chloride with reducing agents; by partly reducing silver oxide or silver carbonate by heat and treating with HCl; by forming suboxide or a subsalt of silver and treating with HCl; by forming suboxide or a subsalt of silver and treating with HCl, followed by nitric acid; by acting on subchloride with nitric acid or an alkaline hypochlorite, etc.; by attacking almost any soluble salt of silver with ferrous, manganous or chromous oxide, etc., followed by HCl; by reducing silver citrate by hydrogen and treating it with HCl; by treating a soluble silver salt or almost any silver solution with potash or soda and almost any reducing agent, cane sugar, milk sugar, glucose, dextrine, aldehyde, alcohol, etc., and supersaturating with HCl; there is no organic easily oxidizable substance that I have tried that has failed to give this reaction. Also almost any salt of silver exposed to light, treated with HCl and then with hot strong nitric acid, yields it. Almost any of these classes represents a long range of reactions, each susceptible of endless variation. In fact, the more the matter is studied, the more extended the range of reactions is found to be that give rise to the formation of this substance. To show how slight an influence will lead to the production of red chloride instead of white, if freshly precipitated argentic oxide is mixed for a few moments with starch or tragacanth paste, and is then treated with HCl, the result is, not white, but pink silver chloride. Even raw starch flour mixed with silver oxide will in a few moments cause it to give a pale flesh colored chloride with HCl. Boiled starch or tragacanth paste does this more quickly and acts more strongly, even in the cold, and still more if heat is applied.

Although red is probably the most characteristic color of this substance, so that I have spoken of it above as red chloride, nevertheless this hardly seems a proper name for a substance that is often purple, chocolate, or black, sometimes brown or even ocherous, sometimes lavender or bluish, and is probably capable of assuming every color of the spectrum. To call it argento-argentic chloride would infer a stoichiometrical composition that, as already mentioned, seems very uncertain; too much so to serve as the basis of the name. Therefore, and as these substances have been hitherto seen only in the impure form in which they are produced by the continued action of light on the normal salts, it might be convenient to call them photosalts, photochloride, photobromide, and photoiodide instead of red or colored chloride, etc., and thus to avoid the inexactness of applying the term red chloride to a substance exhibiting many other colors.

Photochloride by Action of Alkaline Hypochlorites.

Black or purple black chloride is easily obtained by the action of an alkaline hypochlorite on finely divided silver, such as obtained by reduction in the wet way. Commercial sodium hypochlorite may be used to act on it. It is to be poured over the silver, and after standing a few minutes, is to be replaced with fresh. After an hour or two this is again to be replaced with a new portion, which is to be allowed to act half an hour to insure the total conversion of the silver. The product varies somewhat in color, is sometimes black, oftener purple black. If the treatment with hypochlorite has been thorough, strong cold nitric acid of 1·36 sp. gr. extracts from it no silver. This reaction with nitric acid is important, as it shows that not only metallic silver was not present, but that the product contained absolutely no uncombined subchloride. For if any were present, it would instantly be decomposed by the acid, in which one-half of its silver would dissolve. The action therefore appears to take place in this way. First subchloride is formed, part of this is further chlorized into normal chloride, which at once combines with other subchloride, thus taking it out of the further immediate action of the hypochlorite, and this goes on until an equilibrium is reached and neither metallic silver nor uncombined subchloride is left, as is proved by the action of nitric acid. Alkaline hypochlorite, as will presently be shown, attacks uncombined subchloride very rapidly, the combined very slowly; by many days' contact the quantity of combined subchloride is gradually reduced.

Prolonged treatment with hot strong nitric acid destroys all the varieties of photochloride. The time needed varies a good deal. A specimen of that obtained with hypochlorite required twenty-five hours' heating with acid of 1·36 in a water bath at 212° F. to bring it to the condition of white normal chloride. Considering that cold dilute nitric acid instantly destroys freshly precipitated argentous chloride in the free state, this long resistance to strong acid at the temperature of boiling water must be considered most remarkable.

When the red or photochloride is formed with the aid of a ferrous salt or ferrous oxide, I prefer to boil the product with dilute HCl to get rid of the last traces of iron, after a preliminary treatment with hot dilute nitric acid has removed silver and uncombined subchloride. The photochloride will sometimes even resist boiling aqua regia for a time.

Protected from light, photochloride is perfectly stable. Specimens obtained eighteen months ago appear to be quite unchanged.

When treated with ammonia, it is far more slowly attacked than the normal. The ammonia dissolves the normal chloride only. The union between the two must therefore be broken up, and this takes place slowly. The first action of the ammonia is to change the red or purple color to greenish black and then to slowly dissolve out silver chloride. Hours are required even with a large excess of ammonia. While this is going on, if the ammonia is poured off and replaced with nitric acid, the original color reappears. If the action is continued sufficiently long, silver only remains and dissolves readily in nitric acid. A little short of this, treatment with nitric acid leaves a black residue of dark chloride mixed with metallic silver. The dark chloride being insoluble in any acid has led to some strange mistakes in a similar reaction which occurs in treating with ammonia silver chloride that has been exposed to the light. Even a theory has been had recourse to of a "passive condition" of silver. This passive silver is simply black chloride.

A specimen of purple black chloride was treated with warm strong aqua regia until whitened by conversion of the subchloride to normal. By this treatment 2·563 grammes of photochloride gained nine milligrammes, indicating the presence of 2½ per cent. of subchloride, or more exactly:

Subchloride	2·49
Normal chloride	97·51

This is not to be taken in any sense as representing a constant composition. The proportion of subchloride varies between certain limits, not only according to the method of preparation used, but independently of it. Another specimen of black chloride formed with hypochlorite gave figures that indicated a content of less than half of one per cent. subchloride.

Photochloride by Reduction of Normal Chloride.

This is an excellent means of obtaining red chloride. The white chloride is to be dissolved in ammonia and ferrous sulphate added, producing an intensely black precipitate. After standing a minute, the mixture is to be treated with dilute sulphuric acid until it shows a strong acid reaction.

The precipitate is to be first well washed by decantation, then boiled first with dilute nitric, then after washing with dilute hydrochloric acid, which must of course be thoroughly washed out.

The product obtained in this way is often of singular beauty. It might easily be taken for metallic copper. Sometimes it is as rich and bright in color as the copper obtained by electric deposition. Every one knows the richness and brilliancy of that form of copper, and I have seen it fully equaled by this silver salt.

The beauty of the color depends always on the thorough removal of any metallic silver that may be present, and still more on getting rid of every trace of iron. The boiling with dilute hydrochloric acid should be continued until, after thorough washing, a fresh treatment extracts no more and the acid remains colorless in presence of alkaline sulphocyanide.

Instead of an ammoniacal solution of silver chloride, we may make a solution of any other silver salt in ammonia and reduce it in the manner just described with ferrous sulphate. But in this case hydrochloric acid must be used instead of sulphuric after the reduction. This single reaction includes an almost endless variety of methods. The acid with which the silver was originally combined seems to be not without influence on the result; in some cases, for example, with arseniate and molybdate, the action of colored light on the red chloride seems to be somewhat modified. Silver phosphate, on account of the ease with which it suffers reduction, is very well adapted for this treatment.

Photochloride by Partial Reduction of Oxide by Heat, and Treatment with HCl.

This method has the advantage of avoiding all admixture of foreign substances, the last traces of which are very hard to get rid of, and seem to exert an effect on the color disproportionate to their quantity. Accordingly, the photochloride obtained in this way is very beautiful, the shades are from pink to copper red, and a tint resembling burnt carmine.

Heat may be applied to the oxide in either of two ways—long-continued heat at 212° F., or near it; or the change may be effected by roasting.

When slow heat is to be applied, care must be taken that the oxide does not carbonate itself, which it easily does superficially. This is an objection because the carbonate, under these circumstances, yields white chloride, with which the other becomes mixed. The air of a drying oven heated by a gas burner is especially bad in this respect. I have seen a surface of oxide form a coat of yellow carbonate in a few hours in this way. (Most oxide that has been kept some time will effervesce briskly with an acid.) The method is uncertain, sometimes giving strongly colored products and sometimes pale pink.

The oxide may be roasted in a shallow flat-bottomed porcelain basin. With a very moderate heat it changes from brown to black. When this is thoroughly accomplished, and before gray reduction sets in, the oxide is to be treated with HCl. If this be done in the basin itself after cooling, and without disturbing the position of the oxide, a curious variety of tints will be noticeable, depending upon slight differences in the heat affecting different portions.

Silver carbonate may be roasted in the same way as silver oxide, and yields a similar product. By heat its color changes from yellow to black. It is probable that the carbonic acid is driven off at a lower temperature than that at which oxide is reduced to silver, and that with it escapes part of the oxygen. The residue is converted by HCl into deep red chloride.

Action of Various Metallic Oxides on Silver Oxide.

If we precipitate ferrous oxide with potash and add to this silver oxide, or what amounts to the same thing, if we add to ferrous sulphate potash in excess and pour over this silver nitrate solution, the silver oxide separated by the potash is partly reduced by the ferrous oxide, and when treated with HCl forms red chloride, the intensity of the color of which depends within certain limits on the amount of reduction of the silver oxide.

Similarly, if we treat solution of manganous sulphate with excess of potash and then add silver solution, we get an analogous reaction, except that it is much weaker and heat is necessary.

With chromous oxide the action is still weaker, but evident. With cobaltous oxide it is scarcely perceptible without heat and long-continued action.

Action of Ferric Chloride on Metallic Silver.

It has been long known that silver was blackened by ferric chloride, and this action has been proposed in the text books as a means of obtaining subchloride, for which it is quite unsuited.

Ferric chloride acts on silver much as sodium hypochlorite does, but less rapidly. With hypochlorite the action is complete in a few hours, or often in an hour or less; with ferric chloride one or two days are required before the product ceases to yield silver to hot dilute nitric acid. In both cases the action appears to be alike in this: that no subchloride is finally left uncombined with normal chloride.

The product is an intensely dark purple black, when the action takes place in the cold. With heat continued for many hours, ferric chloride can be made to attack the purple salt and gradually convert it into AgCl. With a strong solution in large excess kept at or near 212° F. for sixty hours, the color was gradually reduced to pink and finally to a dingy pinkish gray. Pure white cannot be obtained, as it can by aqua regia.

In order to observe more exactly the course of the action, a strong solution of ferric chloride was allowed to act on reduced silver in fine powder for four minutes, and then a fresh portion (always in large excess) for the same time. Analysis showed that at this stage of the action the material contained:

Ag (determined)	76·07
Cl (by difference)	23·93
	100·00

If we suppose that all the silver was combined with chlorine, the constitution of the substance would be:

AgCl	92·49
Ag_2Cl	7·51
	100·00

But this was probably not the case. There was almost certainly free silver present, and consequently a less proportion of subchloride. Another specimen, treated repeatedly with hot acid until every trace of free silver was removed, was found to contain 1·52 per cent. of subchloride, color purple. Another similarly treated contained 7·3 per cent. subchloride.

(*To be continued.*)

PRACTICAL PHOTOGRAPHY.

THE amateur is sometimes perplexed to know how to arrange the room which he is to use for developing his negatives. We think we may be able to render his task easier by indicating to him the essential parts, so to speak, of such an organization.

In the first place, it is necessary that the room that is to serve as a laboratory shall be perfectly guarded against the intrusion of the least white light. In fact, it is well known that light acts upon the preparations used in photography, and that in order to manipulate these substances it is indispensable to make use of colored glass, this having precisely the effect of eliminating all the active rays. All fissures and cracks, all apertures whatever, even the smallest, should be closed with the greatest care. Double thick paper or black cement will be very useful to us for this purpose.

In order to judge well of the manner in which the work has been done, it is necessary for one to shut himself up in the laboratory for some minutes. This rests the retina, and if there is the least light, it will be perceived that everything has not been seen at first.

The amateur will next have to occupy himself with the questions of light, water, and internal arrangement. Let us examine these various points:

1. *Light.*—The light may be either natural or artificial—natural if daylight be used, artificial if we use some luminous source. In either case, the light must pass through colored glass. Red glass is generally adopted, since the rays that it lets pass have scarcely any action upon the sensitized surfaces. Yet it must not be thought that *all* red glass is equally good; such is not the case, for there is a *yellowish* red glass which is inferior to other shades. Nevertheless, it is but just to acknowledge that the quality of red glass has much improved within a few years, several manufacturers having decided to make it especially for photographic purposes. Nothing is simpler, from an experimental point of view, than to ascertain the quality of the glass. The amateur should never fail to make the test after his laboratory has once been organized. It suffices to put the glass in a negative frame, and then to place the latter, half open, at the spot where it is to be used—either in front of the aperture that admits the light or in front of the lantern. In four or five minutes (a period corresponding to an ordinary development) he ought not, in developing, to find any appreciable difference between the part of the glass that has been illuminated and that which has not been. Were it otherwise, there would be a film on his negative, and in such a case he would have to change the glass or to superpose another one. In most cases the latter method would suffice.

The intensity of the luminous source, too, can be diminished either by a more or less transparent screen, or by regulating the flame in the case of an artificial light. Upon the whole, it is not as to the quantity of light that it is necessary to be particular, but as to its quality.

If it be asked us what sort of illumination is preferable, we answer that it is better to make use of an artificial one, for the reason that it is always the same

—a very important matter in ascertaining the intensity of a negative. It often happens, too, that it is necessary to do the developing at night, when solar light is absent.

It has been proposed to replace the red glass, which, it is said, fatigues the eyes in the long run, by a combination of red and green glass. Such a combination may prove advantageous with an artificial light that

FIG. 1.—DEVELOPING TABLE.

contains less chemical rays than the light of day. With the latter, this arrangement does not give good results.

2. *Of the Water.*—Water is indispensable in the laboratory. It should, of course, be of good quality. Stagnant or putrid water, or water contaminated with the refuse of factories, as well as sea and mineral water, should be rejected.

Well, rain, spring, and river water are all equally

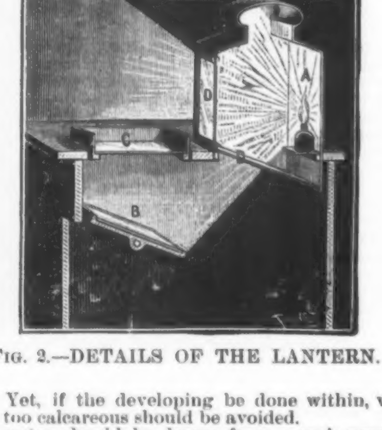


FIG. 2.—DETAILS OF THE LANTERN.

good. Yet, if the developing be done within, water that is too calcareous should be avoided.

The water should be drawn from a cock provided with a rose. Under such circumstances, the washing will be effected with the greatest facility. Under the cock there should be placed a sink for the reception of the baths and washing water.

3. *Of the Internal Arrangement.*—In substance, it is necessary to have a table, a closet, and a few drawers

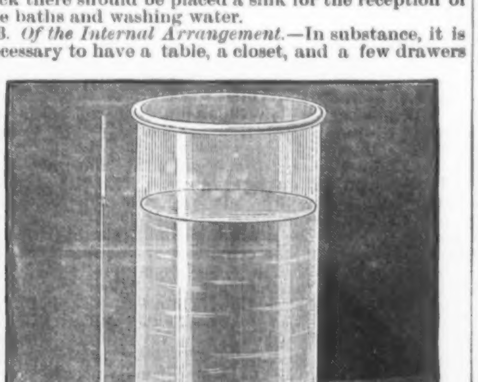


FIG. 3.—VESSEL FOR DECANTING TONING BATH.

and shelves for holding the vessels used. The arrangement will be complete if the amateur has a balance for keeping the vessel in motion during development. It is, in fact, recognized that such a mode of procedure is very advantageous.

We have had a piece of laboratory furniture made which we think is destined to permit the amateur to establish himself in any dark room whatever. With a supply of water and a sink, he will find himself at once equipped. This piece of furniture, which any workman can construct, consists (Fig. 1) of a table mounted upon two supports containing drawers and receptacles for the vessels. The drawers are for the reception of the plates and various other objects that must be protected from dust and light.

Upon the table are placed the various reagents necessary. In the center there is a lantern with red glass, and in front there is a tilting box designed to receive the disk during development. A strong counterpoise fixed to the box permits of making the latter rock, through the aid of the finger, with the greatest ease.

The lantern (Fig. 2) is provided with two red glasses, one of them vertical and the other at an angle of 45°. The first permits of direct illumination and the second of illumination beneath. To this effect, a mirror, B,

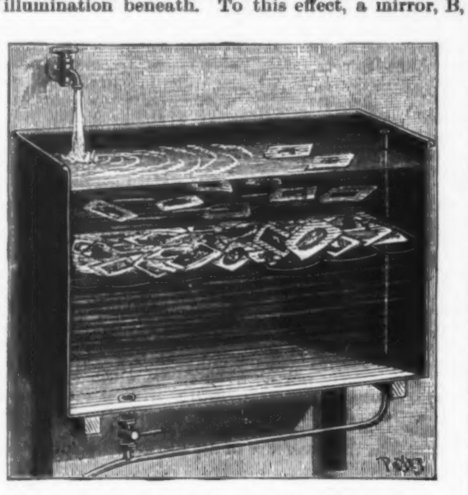


FIG. 4.—TROUGH FOR WASHING PRINTS.

at 45°, situated beneath the tilting box, receives the rays from the lantern and projects them upon the plate that is in the course of development.

The box is of metal and has a thick glass bottom, and the disk also is of glass. In this way it is possible to judge as to how the negative is coming out, and of its intensity, with the greatest ease, without removing the plate. The mirror is mounted upon an axis that permits it to pivot. In this way the lighting can be effected at the moment desired.

This system of examining the negative without being obliged to take it from the developer appears to us to be very advantageous, seeing especially that an examination by transmitted light is the only one in which confidence can be placed. Direct examination often becomes impossible when a negative has had a full exposure and exhibits no great contrasts; and an examination of the back of a negative, in order to see whether or not the image has traversed it, does not seem at all to us a sure criterion, since the thickness of the gelatine varies greatly, according to the manufacture, and thus great errors may be made.

Taking Proofs.—In most toning formulas it is necessary to decant the gold bath. This is a very delicate operation for persons who are unfamiliar with chemical manipulations. The following is an arrangement that renders the operation extremely simple. We take a vessel provided with a tubulure at about two centimeters from the bottom, so that the deposit may settle beneath it. Into the tubulure is inserted a rubber stopper containing an aperture in which is fixed a bent glass tube that runs to the top of the vessel. The gold bath is prepared in this vessel. After the deposit has collected, there is nothing to be done but to turn the tube downward in order to draw off the upper part of the liquid in an absolutely limpid state.

Washing the Proofs.—We shall now describe a style of trough which is easily made, and which permits of washing a large number of prints at once. It is of wood covered with lead (I never use zinc), and is divided into two parts by a wire netting that prevents the prints from sinking to the bottom. The water enters from a cock above, and a waste pipe regulates the level. A purge

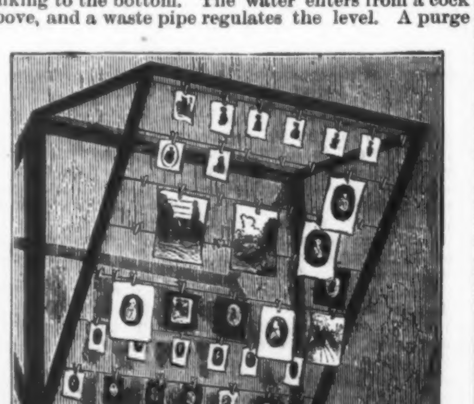


FIG. 5.—PRINT DRIER.

cock beneath permits of the trough being quickly emptied.

The prints are placed in the upper part, the trough being full of water. The cock being open, the proofs are kept in constant motion, and as the hyposulphite of soda is denser it settles at the bottom. The trough is occasionally emptied to the level of the netting, for the sole purpose of preventing the prints from adhering to each other. Then the supply cock is again opened. In this way the washing is effected very perfectly.

Drying the Prints.—It is easy to dry the prints by simply suspending them from taut cords by means of wooden clips (Fig. 5). If we have to do with silver prints that have a tendency to curl, the trouble may be remedied by putting the proofs back to back. Under such circumstances, they will remain sufficiently flat. The drying should be done in a well-aired place. —*A. Londe, in La Nature.*

THE VELOCITY OF PROPAGATION OF FLAME.*

By LEWIS T. WRIGHT, Assoc. M. Inst. C. E.

I WANT to call your attention particularly to the fact that sometimes flame travels rapidly and sometimes slowly. This subject is one of some importance, and is what we call "the velocity of propagation of flame." We can prepare, with coal gas, mixtures having flames that travel at from 6 feet to 1 foot per second. And I wish you to distinguish between the quiet, uniform, and slow propagation of flame that takes place in the first half of this 13 foot glass tube, which is measurable to the eye, and the extremely rapid and detonating explosion sometimes occurring in the second half of the tube. The first I will call an explosion of the "first order," the second—infinitely more rapid—I will call an explosion of the "second order." Let us suppose I have an explosion of the first order taking place in this tube, that does not exceed the velocity of 4¼ feet per second. I can arrest it—put it out—by inserting a small piece of metal gauze in the tube. We learn, then, that when the flame is traveling at a speed of less than 4¼ feet per second, the gauze will arrest its passage. I will now endeavor to prepare a more explosive mixture, having a velocity of propagation of flame of more than 4¼ feet per second, and you will, perhaps, find the flame penetrating the gauze as though it were not there. We have learned a very important fact.

I want to show you, if I can, in a more marked manner how an explosion of the first order becomes connected with one of the second and more terrible kind. Here we have a mixture, the flame of which lodges in the tube, and is not, as at first, a very thin surface of flame, but occupies, perhaps, one-half inch of the length of the tube. This flame is in a violent state of oscillation. When its tremor is sufficiently violent, explosion of the second order will be initiated. There are two points here to observe—that a definite explosive mixture may have a velocity of propagation of flame when it is undergoing explosion of the first order (that is, as low as 1¼ feet per second), but when it becomes sufficiently agitated to give an explosion of the second order, the rate of propagation of flame is several thousand feet per second.

The following table sets forth the particulars of the experiments made in a glass tube 13 feet long and 0·75 inch in diameter:

Mixture.		Lineal Velocity of Efflux of Mixture.	Rate at which Explosion of First Order Travels in Tube.	Total Velocity of Propagation of Flame.
Gas.	Air.			
Per Cent.	Per Cent.	Ft. per Second.	Ft. per Second.	Ft. per Second.
10·3	89·7	1·21	1·1	2·31
12·2	87·8	1·24	2·0	3·24
15·0	85·0	1·28	3 0	4·28
17·7	82·3	1·32	4·8	6·12
19·6	80·4	1·35	3·0	4 35
21·2	78·8	1·38	2·4	3·78
22·1	77·9	1·39	1·3	2·69
23·0	77 0	1·41	Stationary.	....

In thinking of explosive mixture, you must bear in mind the difference due to the mixture and that due to the class of explosion. Some years ago I was connected with a large gas works, and there we had a great number of safety lamps, as there were innumerable places where it would have been fatal to enter with a naked light. The lamps were in the charge of a most competent man, and were carefully examined and tested before being sent out for use on the works. Well, one morning before daybreak a large purifier exploded just as the men were going to work on it. One man, who was carrying a safety lamp, was knocked down, and others were burned. The lamp in its fall had its gauze injured. The explosion was looked upon as most mysterious, and some thought that the hole in the gauze had not been caused by the fall of the lamp on a sharp piece of iron, but had been there when it left the lamp room. It was an unpleasant occurrence that never became satisfactorily cleared up. Among experienced men there had always been a feeling of distrust regarding these lamps in circumstances where there was known to be much gas about, and an old hand might be known by his habit of leaving his lamp outside if called upon to enter any building in the dark where gas was escaping. Some time after a similar explosion occurred by a young man placing a safety lamp near a current of gas, which ignited, burning him severely. The lamp was rigorously examined, but no defect could be found in it, and it stood the test well. I may say that the test was really inefficient.

I determined to thrash the matter out, and, trying the lamps by various methods, at last found out a means of blowing them all up. Not one could resist the new test, which was simply this: By creating an explosion inside the lamp, by a sudden application of the explosive mixture to it, the flame was passed through the gauze, igniting the mixture outside. This was a serious revelation, and exposed the deficiencies of the old test for soundness, which was, that the lamp should be put out by being smothered with gas. I am about to show this experiment in an exaggerated manner. Here we have a hollow tin vessel covered on the top with gauze. I am going to create an explosion inside it; and I hope you will be able to see the flame as it passes through the gauze. That the flame is projected some distance I will prove by causing it to light an unignited stream of gas at a distance of four feet. I found out that the Davy lamp gauze would not always resist the passage of the flame resulting from a small explosion in the lamp. Of course nowadays we know much more of the Davy lamp than we did, and the ordinary forms are not considered safe in what we might call moderate currents. In a current of gas

* From the *Jour. of Society of Chem. Industry*. Abstract from a recent lecture.

about four or five feet per second, the flame is blown through the gauze. This is well known, I believe, now; but I do not think the circumstance of an explosion inside the lamp blowing the flame through is so well known. It is evident, then, that when the rapidity with which the flame is mvoing exceeds a certain rate, it is blown through the gauze.

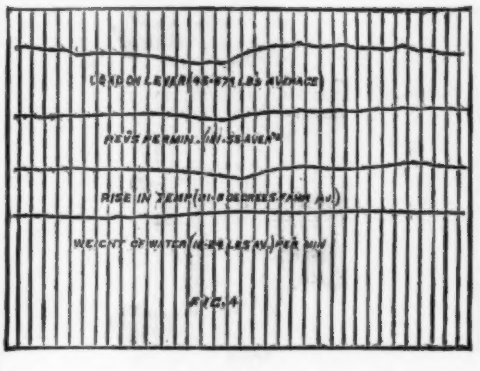
When I discovered that an explosion inside the safety lamp was sufficient, with coal gas at least, to pass through the gauze, I felt I had made an unpleasant discovery, and thought that perhaps there was something wrong with the material. I tried all sorts of makes, of various meshes. There was nothing to choose between them. It was of no use having finer mesh, for this reason: As you reduced the size of the apertures, you reduced the thickness of the wire and its weight, so it was as broad as it was long. Still flame will not touch a cold metal surface. If I hold this flame against this metal plate, there is a space between that is not flame. You will see that as flame (to be flame) must be hot, it cannot touch this cold metal, because the metal will cool it below the temperature at which this gas can give the phenomena of flame. Often, in these tubes, I find if I let the flame go slowly up to the gauze, it is extinguished before it quite touches it. When the flame is traveling in the direction of the gauze, the question whether it will pass or be extinguished is simply a question of the rate at which the flame is traveling and the rate at which the gauze is cooling—a battle between the velocity of propagation of flame and the rate of cooling that the gauze can exert, which will be decided in favor of the most powerful.

Davy lamp gauze is made by interlacing about 28 wires of 15-1000 of an inch diameter, forming the warp over and under 28 wires of woof of the same diameter, and the result is a number of square apertures slightly larger than the thickness of the wire, being about 21-1000 of an inch across. Two adjacent wires of warp are separated from each other by a little more than the thickness of the wire forming the woof, and *vice versa*, because the wires of the woof bend under and over the wires of the warp, just as the wires forming the warp bend under and over the wires of the woof. So you see if, with this system of weaving, we wish to obtain smaller apertures, we must employ thinner and lighter wires, having less cooling power. However, let us suppose that the wires of the woof are very strong, and will not bend at all; the wires of the warp only bend under and over the straight woof wires. Then you see that the warp wires can touch each other, and you get rid of the square apertures. We can also get, by employing very stiff wires one way and very thick, soft wires the other, a heavy gauze, with no direct openings, but small tortuous ones. We can do what we could not do with the other mode of weaving, viz., procure extra weight of metal, at the same time reducing the apertures. This method of weaving is called basket work, because baskets are made like this. By taking off the old Davy lamp gauze from our lamps and replacing it with the heavier basket work, I secured lamps that would stand any test I could apply, and I had gas from a compressing engine, at a pressure of twenty pounds and upward per square inch, blown on them, and they did not fire. My object of procuring a safe lamp was satisfied, and I may say that attempts to make the lamp safe by using two or three instead of one layer of the ordinary Davy lamp gauze were not successful.

EXPERIMENTS ON THE "MECHANICAL EQUIVALENT OF HEAT" ON A LARGE SCALE.

By E. A. COWPER and W. ANDERSON.*

THE extremely interesting experiments of Dr. Joule on the mechanical equivalent of heat led one of the authors of the present paper some years ago to speculate on the possibility of conducting such experiments on a much larger scale. It appeared that it would be possible to employ a powerful machine that would absorb a large amount of power, and to keep it continually going for a whole day at a time, so as to get everything into a thoroughly normal state, and so arrange matters as to eliminate all loss or gain from radiation or conduction. The first idea was to employ an India rubber masticating machine, which would absorb a very large amount of power in a small space, and to inclose it in a small tank, and that again in a larger tank, and then run cold water into the machine, and let the hot water from it run into the small tank so as to entirely surround the machine with hot water of the same temperature as the water coming out, and then let the water from the first small tank flow into the larger tank and from that to waste, the outside tank being kept up to the same temperature as the inside tank and the machine, so that the machine should neither lose heat nor absorb it. However, after much consideration it was thought best to employ one of the late Mr. Froude's dynamometers, such as he used for trying the power of marine engines, though on a smaller scale. Accordingly, through the kindness of Messrs. Heenan and Froude, the loan of such a dynamometer was obtained, and it was fitted up at Erith as above indicated, viz., with a small tank inside a larger one,



which last was made of thick wood, and well lagged outside with three thicknesses of hair felt, and this provision was found in practice to be so efficient that the tank of water only lost 2 deg. in 16½ hours when standing, or about 1 deg. in 8¼ hours.

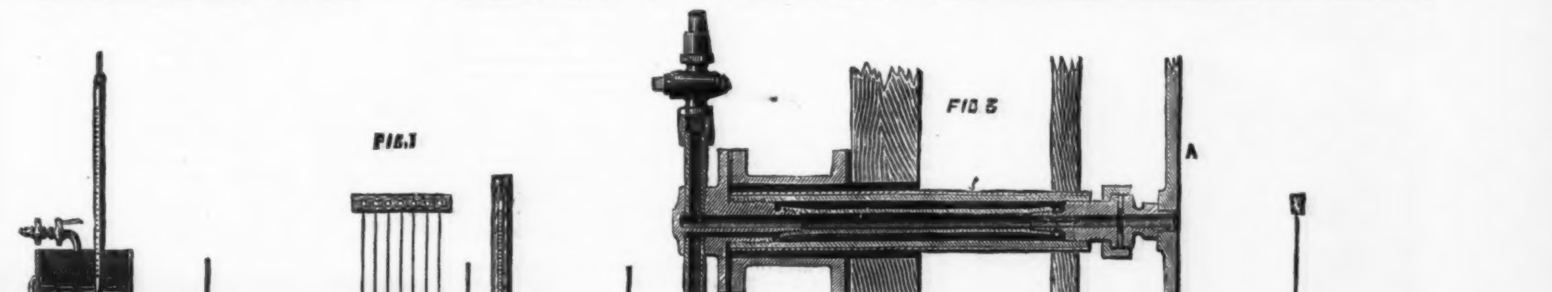
Two very large thermometers, about a yard long, were specially made, having 25 in. to 50 deg., or ½ in. to 1 deg., and these were used throughout for taking the temperature of the cold inflowing water and the hot outflowing water, while other thermometers were used throughout the outside tank to enable it to be kept to the same temperature as the outflowing water. The temperature of the outflowing water was, of course, taken immediately as it flowed out from the Froude's dynamometer, not at the waste. The waste water was carefully taken at short given intervals and weighed, not measured. Several careful observers took observations continually, one took the revolutions of the engine per minute, and the total revolutions by a counter that was always going, and registered every revolution throughout the day. Another observer took the weight lifted by the dynamometer, another the temperature of the inflowing water, another that of the outflowing water, and another the general temperature of the tank, while one in command watched the whole, and saw that every one kept his register closely.

Before entering on the calculations and results obtained, it will probably be more interesting if the apparatus is first described, and it is to be understood that the object aimed at was to employ continuously a large amount of power, viz., about five horse power, and heat a very considerable quantity of water per minute, viz., about a gallon per minute, to a considerable extent, viz., about 20 deg. Fah., while all effects of radiation and conduction were neutralized as far as possible. The Froude dynamometer, colored red in the diagrams, is shown in elevation and end view, and the lever connected with it is also colored red, with its rod and scale for the reception of the weights to be lifted. In the engraving, B is a tank surrounding the dynamometer. C is an outer tank, surrounding the inner tank. This is well clothed outside with three thicknesses of hair felt. D is a small steam pipe to keep the outer tank up to the temperature of the inner tank and dynamometer. The water to be heated is passed into the dynamometer through an India rubber inlet pipe, which is itself jacketed with water of the same temperature as the inflowing water. The pipe, O, is the outlet pipe, where the hot water flows out from the dynamometer. The power for driving the dynamometer is communicated through the shaft, S, and a piece of wood is introduced between the flanges of the coupling in order to prevent the communication of heat either way, though the temperature of this shaft is kept up by the water in the outer tank. Thermometers were placed throughout the apparatus to enable it to be kept at an even temperature.

It will at once be seen how completely loss or gain of heat was prevented, as the temperature of the inner tank was the same as the outflowing hot water from the outlet pipe, O, and the hot water from it flowed into the outer tank, which had a very small quantity of steam, to keep it to the temperature of the hot water from the outlet pipe, O. Thus the outer tank was, so to speak, "down stream," and even if its temperature varied a little, it is impossible to conceive that it could practically affect the temperature of the hot water coming out of the dynamometer, especially as the quantity passing continually was very great, and had thus full command over the temperature of the inner tank. This it was that enabled the apparatus to be kept in a normal state for many hours together, and from which results might be obtained for any given length of time. The only thing that interfered at all with the perfect regularity of the experiment, as checked every five minutes, was a very slight variation in the speed of the engine, and an increase of speed of one revolution per minute on 180 revolutions per minute could at once be detected, and was followed after a few minutes by a perceptible rise or fall in the temperature of the outflowing water, as the quantity passing was always almost exactly the same. The diagrams of the speed of dynamometer, weight lifted, and of the temperature and weight of water heated, Fig. 4, show what these very slight fluctuations were, and when they were contrasted with the large volume of water heated, viz., about a gallon per minute 20 deg., it will be seen how slight they were; and further, as no loss of power on the one hand, or loss of heat on the other, was sustained, it was of minor importance, if, indeed, of any importance, that the fluctuation should be sometimes slightly above and sometimes slightly below the given point, as the total power was accurately registered, as well as the total heat produced. The result showed a "mechanical equivalent of heat" = 769 ft., that is to say, that 1 lb. of water raised 1 deg. Fah. was equal to 1 lb. lifted 769 ft., and it will be remembered that Professor Joule made it 772 ft. It is not to be wondered at that the "equivalent" obtained was slightly lower than that obtained by Professor Joule in his last experiments, as all losses of heat were prevented, and no losses had to be calculated, nor did the specific heat of the apparatus enter into the calculation, as the apparatus was practically kept in a normal state throughout the experiment, and, in fact, for days together.

The authors are aware that the experiments described are by no means complete, and objections may on that account be justly taken to them, but they are anxious to bring the work, so far as it has gone, before the British Association, in order to benefit by the suggestions and criticisms which discussion would not fail to produce. They intend to renew the experiments at no distant date, and feel sanguine that absolutely trustworthy results will eventually be arrived at. A small improvement will be made in the machine before

* Section G, British Association. The *Engineer*.



APPARATUS FOR DETERMINING THE MECHANICAL EQUIVALENT OF HEAT.

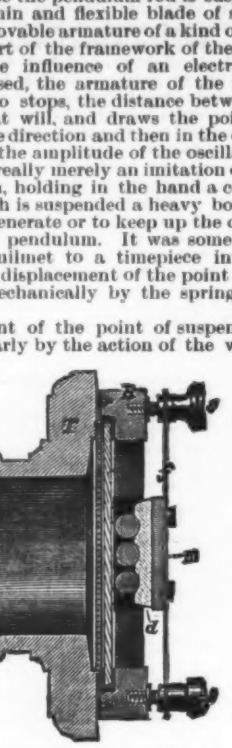
prosecuting further experiments, viz., certain precautions to prevent the possibility of any heat being taken up from the surrounding water by any part of the dynamometer that may be slightly below its general temperature close to the point where the cold water enters.

THE MIX AND GENEST MICROPHONE.

IN some of the German government telephone stations which have been established in connection with the telegraph service, a new microphone is now coming into use. This is represented in the annexed illustration, which we reproduce from our contemporary, the *Elektrotechnische Rundschau*. The leading ideas in the construction of this microphone were, first, to avoid accidental derangement in the adjustment of the parts, and, secondly, to produce an instrument which is free from jarring noises.

In the Ader microphone the carbon cylinders are loosely supported, and under vibration disturbing noises are easily produced. In the microphone designed by Messrs. Mix and Genest the diaphragm is vertical, and the carbon cylinders are prevented from revolving by a kind of brake. The construction will be clearly

FRONT ELEVATION.



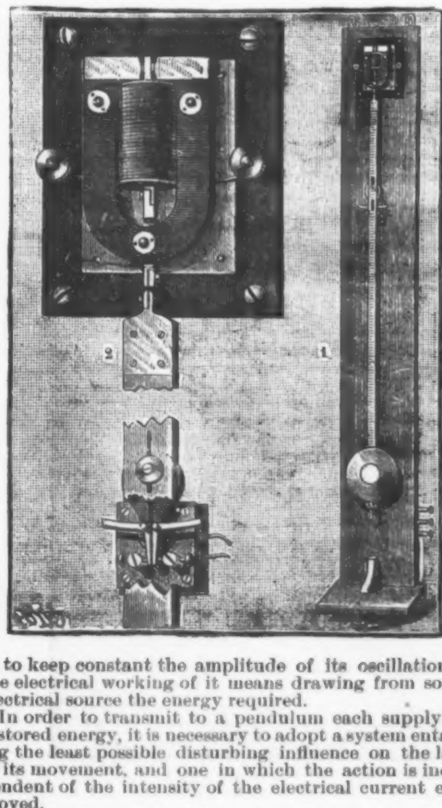
VERTICAL SECTION.

THE MIX AND GENEST MICROPHONE.

seen from our illustration. Between a cast iron ring, R, and the mouthpiece, T, is inserted a diaphragm, M, consisting of pine wood, and held by the clamps, *a a*'. Upon this diaphragm are fastened two carbon holders, *b b*, which serve as journals for the three carbon cylinders, *k*. Across the face of the diaphragm is placed a spring, *f*, provided with a gun metal piece, *m*, to which is attached a layer of some soft material, preferably felt, such as is used for coating the hammers of a pianoforte. This layer of felt acts as a brake, and the pressure can be increased by tightening the screws, *s s*'. The resistance of this transmitter is about 4·5 ohms. The primary coil contains 250 turns of 20 mils wire having a resistance of 1 ohm, while the secondary coil contains 2,900 turns of 5 mils wire having a resistance of 200 ohms. We may state on the authority of Herr Grawinkel, one of the officers in the administration of the German telegraphs, that speech by means of this microphone is transmitted very clearly and sharply to a distance of 120 miles over an ordinary iron telegraph wire, and to a distance of 15 miles through an underground cable.

IMPROVED ELECTRIC PENDULUM.

THE keeping up of a pendulum consists in restoring to it, in proportion as it loses, the energy absorbed by friction with the air and resistances of suspension, so



as to keep constant the amplitude of its oscillations; the electrical working of it means drawing from some electrical source the energy required.

In order to transmit to a pendulum each supply of restored energy, it is necessary to adopt a system entailing the least possible disturbing influence on the law of its movement, and one in which the action is independent of the intensity of the electrical current employed.

The method employed by M. Carpentier, and described in *La Nature*, is shown in the accompanying figure, both in its complete form and with the details of the mechanism, and it consists in slightly displacing periodically the point of suspension of the pendulum horizontally and in the plane of the oscillations.

For this purpose the pendulum rod is suspended by means of a very thin and flexible blade of steel, dovetailing into the movable armature of a kind of polarized relay, forming part of the framework of the pendulum itself. Under the influence of an electric current periodically reversed, the armature of the relay oscillates between two stops, the distance between which can be reduced at will, and draws the point of suspension first in one direction and then in the other, thus keeping constant the amplitude of the oscillations.

This method is really merely an imitation of what we are led to do when, holding in the hand a cord at the extremity of which is suspended a heavy body, we endeavor either to generate or to keep up the oscillations of this improvised pendulum. It was some time ago applied by M. Guilmet to a timepiece invented by him, in which the displacement of the point of suspension is effected mechanically by the spring action of the clockwork.

The displacement of the point of suspension takes place perpendicularly by the action of the weight; its extent does not depend on the intensity of the current working the relay.

The periodical reversing of the current is effected by a commutator placed on the wood that serves as a framework to the pendulum, and actuated by the pendulum itself. It is due to the reciprocal action exercised from a distance between a small magnet fixed to the pendulum rod, and drawn along by its movement, and a piece of iron belonging to the commutator. The latter is in the form of the arc of a circle, the center of which coincides with the axis of suspension of the pendulum. Thus the magnet or the pendulum rod moves opposite to it, without any variation in the small distance separating them. The arc of iron is mounted in the middle on an axle placed in the symmetrical plane of the apparatus, and while the point of application of the attraction that it undergoes from the magnet passes alternately from one part to another of the articulation, we get a series of swinging movements synchronous with those of the pendulum. These movements, limited by stops, are so reduced as to be imperceptible, but they are sufficient by changes of contact to bring about the reversal of the current.

As to the reaction that the pendulum undergoes, it is evident that, being to all intents normal at the iron arc of the commutator, it passes through the suspension, which is a fixed point, and that its influence is thus almost eliminated.

Thus we see that the pendulum maintains itself in motion, being completely cut off from all material connection with other bodies. There only exists a magnetic connection between itself and the commutator. This connection no doubt absorbs a certain amount of energy, but the loss in this respect is really inappreciable in comparison with the resistance of the air and those of the suspension. In systems where the commutation is effected by mechanical means, the reverse takes place, and the working of these organs is the main cause of stoppages, for really the pendulums in such systems require at each oscillation a much greater re-enforcement of energy than this one. Now, if this restoration has a disturbing influence of the law of movement of the pendulum, is not the reduction of it an advantage?

To give an idea of the result at which the inventor has arrived, it is sufficient to remark that this pendulum is kept at work by means of a displacement of the point of suspension amounting to 0·02 millimeter at each oscillation.

Without entering into an examination of the possible applications of this apparatus, we may remark that for the distribution of the time in towns it fulfills a condition generally required, the emission of a current periodically reversed.

THE JAPANESE MAGIC MIRROR.

By Dr. R. F. HUTCHINSON.

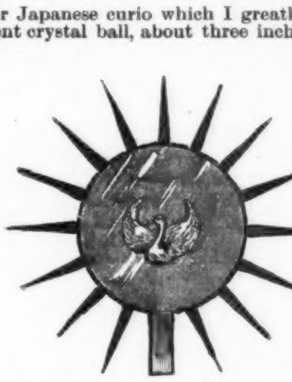
I HAVE, at last, realized the longings of my boyhood, and am in possession of a Japanese magic mirror. I have a hazy recollection of an attempt—I think, by Sir D. Brewster—to solve the mystery to the learned, but its effect on me was to sink me deeper in the mire of mystification. Even now, after repeated and careful experiments, I am *in statu*, and can offer no explanation of the optical mystery, nor can many to whom I have exhibited it. If you, or any of your readers, can enlighten me, I shall be deeply obliged.

I send you a rub of the back of the mirror, which will help you to understand the magic. The body is bronze, the face is said to be steel. It may be silvered, and, as far as I can make out, is quite plane. Your face is reflected, as in any other mirror, though perhaps not so clearly as in our own looking glasses.

On the reverse a goose or swan is stamped out in relief, enveloped in its own plumage, and standing out about about 0·05 inch above the checker work of the ground. Now for the mystery. Reflect the sun with an ordinary plane mirror, and you obtain a replica of the face of the mirror on the wall, slightly smaller than the original. Reflect the magic mirror, and you see, not the replica of the face, but the image of the goose, surrounded by a glory of triangular rays. And, what is very strange, you do not see the image you have on the reverse, but another one altogether. Thus, you see a dot on the beak, which is non-existent in the image at the back, and you do not see the drop of ink which you may place on the neck; further, you do not see the surrounding checker work, on the wall. Now, how is this? I cannot explain.

Another very remarkable phenomenon is witnessed on handling the mirror in sunlight. You are distinctly aware of *two* surfaces, and, if you move the mirror, the particles (?) of the two surfaces pass each other in opposite directions, like microscopic iridescent aerolites; one shown passing say from north to south, and the other in the opposite direction. This is very strange to see. Further, if you look for a second at the surface in the sun, *you* cannot see the bird, *but your companion sees it on your face.* The natives to whom I have shown it are amazed, and regard it as witchcraft (*jadugari*).

Another Japanese curio which I greatly value is a magnificent crystal ball, about three inches in diame-



THE JAPANESE MAGIC MIRROR.

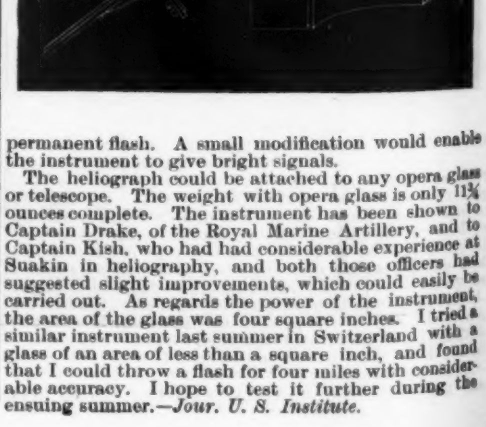
ter; and this, too, is great medicine to the natives, exhibiting, as it does, a lovely miniature panorama of the surroundings; but what amazes them is that, though cold as ice, they cannot hold it in their hands in the sun, inasmuch as it burns like fury, and I often have to save it from being dropped by them like a hot potato. —*Knowledge.*

A NEW HELIOGRAPH.

By THOMAS H. BLAKESLEY, Esq., M.A., C.E., Royal Naval College, Greenwich.

SOME time ago I had occasion to turn my attention to the construction of an instrument which should be portable and at the same time capable of throwing a flash to any given visible point, and one so far distant (five, ten, or more miles) that there was no means of following the path of the ray by the eye itself. The arrangement carried out in the instrument exhibited to a certain extent fulfills that requirement. The objects of the heliograph were two—first, to send a ray in the direction desired; and secondly, to have some test by which the sender was sure that the ray reached the desired spot.

The fulfillment of these conditions in the instrument exhibited depended upon the fact that, if two mirrors are placed at right angles, and receive portions of the same beam of light in such a way that the direction of the beam is at right angles to the line of intersection of the mirrors, the two portions of the beam would be reflected in directly opposite directions. If such a system of mirrors is placed at the end of a telescope or tube directed to any spot, and be turned about the axis of the tube and about the line of intersection of the mirrors, until an eye looking through the tube receives an image of the sun from one mirror, this fact will serve as a test that the portion of the beam from the other mirror is reflected in the direction of the tube. In the instrument shown, the mirror nearer the telescope was merely a piece of unsilvered glass. The two mirrors are kept up to perpendicularity to each other by a spring. The near mirror may be clamped, and signaling carried on by forcing the further mirror out of its position. This plan would give signals as breaks in a



permanent flash. A small modification would enable the instrument to give bright signals.

The heliograph could be attached to any opera glass or telescope. The weight with opera glass is only 11¾ ounces complete. The instrument has been shown to Captain Drake, of the Royal Marine Artillery, and to Captain Kish, who had had considerable experience at Suakin in heliography, and both those officers had suggested slight improvements, which could easily be carried out. As regards the power of the instrument, the area of the glass was four square inches. I tried a similar instrument last summer in Switzerland with a glass of an area of less than a square inch, and found that I could throw a flash for four miles with considerable accuracy. I hope to test it further during the ensuing summer.—*Jour. U. S. Institute.*

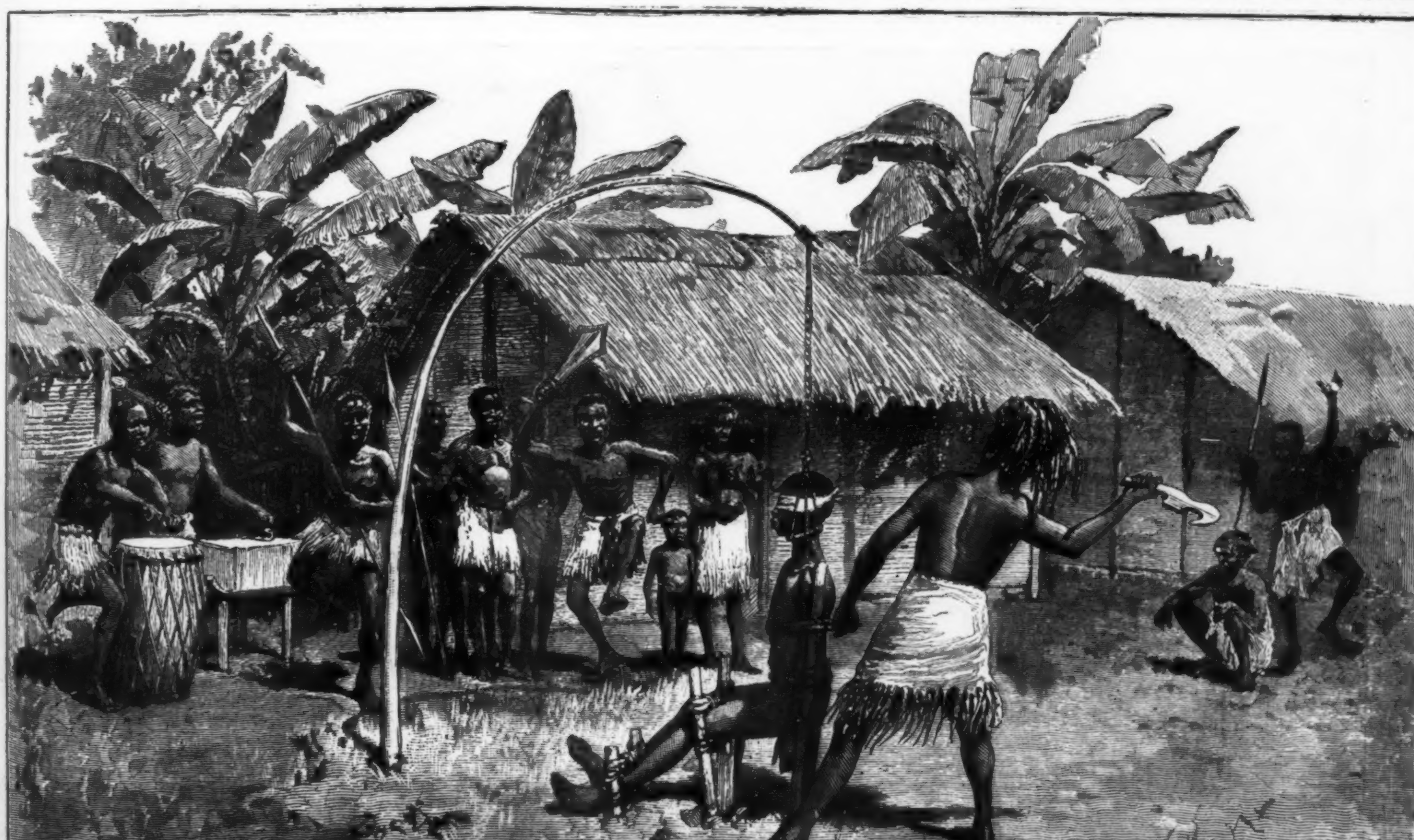
THE BA-YANZI.

The readers of Mr. H. M. Stanley's and Mr. H. Johnston's books on the Congo region and its native inhabitants will remember the descriptions of Isanghila, one of the most promising stations of commercial colonization, situated about thirty miles above Vivi, and at a point where the navigation of the river upward begins to clear itself from the obstacles interposed by the cataracts that impede its course for a considerable distance below. Isanghila is also a place of some importance with regard to intercourse with the population of the upper region as far as the equator, for here the tribes along the river belong to the Ba-yanzi race, whose language and habits differ in many respects from those of the Lower Congo.

Their heathen and savage condition is sufficiently deplorable; and some of the sketches of the Ba-yanzi show the grim and ugly aspect of native barbarism, while in others it appears merely grotesque. Patriarchal chieftainship, among those nations, implies polygamy and slavery carried to such a pitch of devotion that the wives or women of the chief's household, when their master dies, must expect to be buried alive, with the idea that they are to serve him in the after life, while a number of slaves, the favorite and most faithful, must be slaughtered, that their skulls may ornament the memorial erected to his name, which is, as we see, a conical mound of clay, painted with fantastic figures in colors of ocher. Here is matter for reflection on that most prevailing vice of egotism, which even superior civilization does not wholly eradicate, but which flourishes in savage life to the sublimest perfection; because the great man dies, his inferior dependents are to be put to a horrible death, and in Ba-yanzi social morality this is but right and proper. The monument is made more stately by suspending over it a European umbrella, purchased from some trader at a great price. Mr. Glave contributes the picture of a Ba-yanzi execution, witnessed by himself. It is not the judicial punishment of a criminal. We will give the explanation and description in his own words:

"The revolting custom of human sacrifice is carried on to a horrible extent on the Upper Congo River, principally by the Ba-yanzi tribes. All slaves, both men and women, are liable to this barbarity. These people are under the impression that a man dying in this world is simply transferred to another, there to carry on exactly the same existence, requiring the same food and attendance. Upon the death of a chief, his relatives or friends kill about half his slaves, men and women, to go with him, they say, to attend to his wants and to serve for his protection; it being very *infra dig.* for a chief to make his entry into the next world without a certain following. The women are strangled; a rope is put round the neck of the victim, a man climbs a tree, and ties the rope to a branch, the woman being held up, so that when they let her go she is swung in mid air in her dying struggles. These cause great merriment among the spectators, not thinking that at least a great many of them will share the same fate sooner or later. The men are beheaded, as shown in my sketch. The victim is seated on a log of wood; two stakes are then driven into the ground, one each side of him, and as high as his shoulder; bands are then put round his body, inclosing it in these stakes, then two stakes are driven by his knees, and two by his ankles, one at each side, and he is securely bound to them with rope. A ring of cane is then put round the neck, with several leaders of string, which are drawn up and tied in a knot above his head. A pliable pole, about 18 ft. long, is then driven into the ground 9 ft. from the man's seat. It is bent down, just above the man's head. A small piece of rope is fastened to the top of the pole, and the other end of the rope is made fast to the knot above the man's head. This being now at very strong tension, the whole body is quite immovable, and the neck is stretched to its full extent. The executioner then makes his appearance. He makes a chalk mark on the poor fellow's neck; then, with one blow, severs the head from the trunk. The spectators

A BA-YANZI CHIEF'S TOMB



BA-YANZI SLAVE EXECUTION.

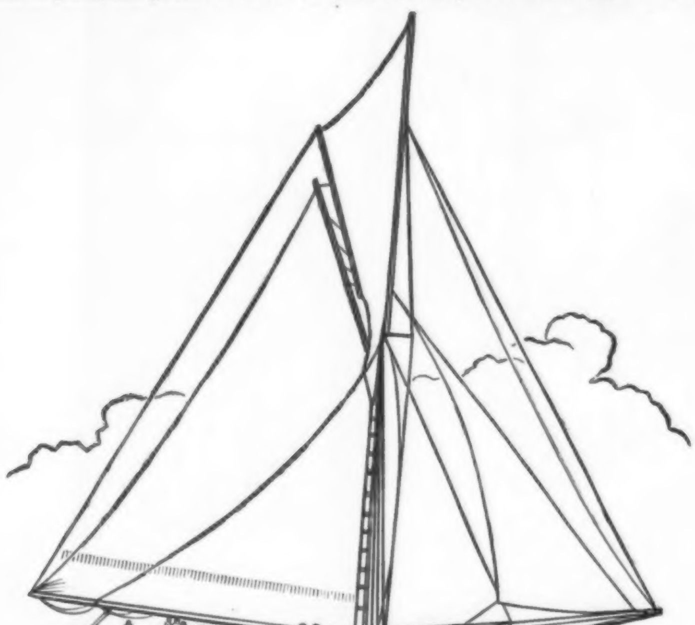
at this seem to lose all control over themselves. They tear down the head from the pole, and there is a ghastly scrimmage for it, often resulting in a free fight."

The Ba-yanzi, however, with all these cruel customs, are superior to some of the other nations of the Congo. They make pottery, neat wooden furniture, and other articles, often decorated with taste, build neat houses, especially at the town of Bolobo, and are skilled in working iron and other metals, fabricating knives and hatchets, which they sell to the Ba-teke and the Wa-buma. They are fond of music; and the tones of their five-stringed lyre, and of the marimba, a sort of dulcimer with thin slips of metal arranged as keys on a sounding board, are sweetly sonorous. They cultivate maize, sweet potato, sugar, tobacco, manioc, banana, the oil palm, and ground nuts for trade, and semi-tropical fruits, such as the orange and pineapple, introduced from the Portuguese of the west coast. They have no horses or oxen, and few sheep, but keep goats, pigs, and poultry. They catch fish in abundance, and preserve them by smoking. The Ba-yanzi are not of the negro race, according to ethnologists, but belong purely to the "Bantu" family, which includes the people around Lake Tanganyika and Lake Nyassa, in Eastern Africa, and on the Zambesi. Their skins are of a chocolate brown color. They are well shaped, and have abundance of hair, but usually pluck out the beard, mustache, and whiskers, eyebrows and eyelashes. They scar themselves on the forehead, breast and belly, and temples, with incised marks denoting the tribe; dye the hair and nails with a red pigment, and stiffen their plaited tresses or pigtails with clay and grease; often stick parrot feathers and various other ornaments about their persons, and wear earrings, nose rings, necklaces, or bracelets, while one or two small pieces of grass cloth suffice for the dress of the "fashionable lady of Lukungu."—*Illustrated London News.*

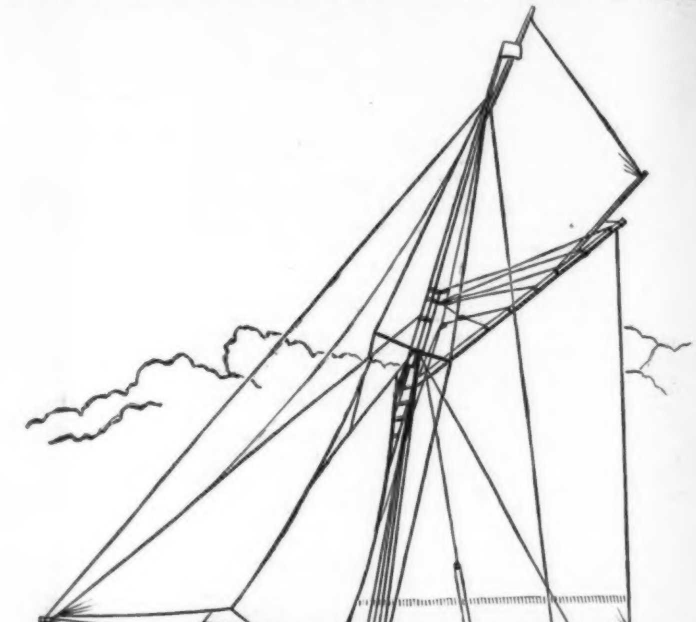
THE INTERNATIONAL YACHT RACE.

THE first of this season's races for the America's cup occurred at New York on Sept. 27, 1887.

The British yacht Thistle, of steel, was launched on April 26, and sailed her first trip on May 12. In her building and launching the utmost secrecy was preserved, and at once the most marvelous stories of her speed began to appear. She sailed in fifteen races on the other side, winning eleven firsts, one second, one



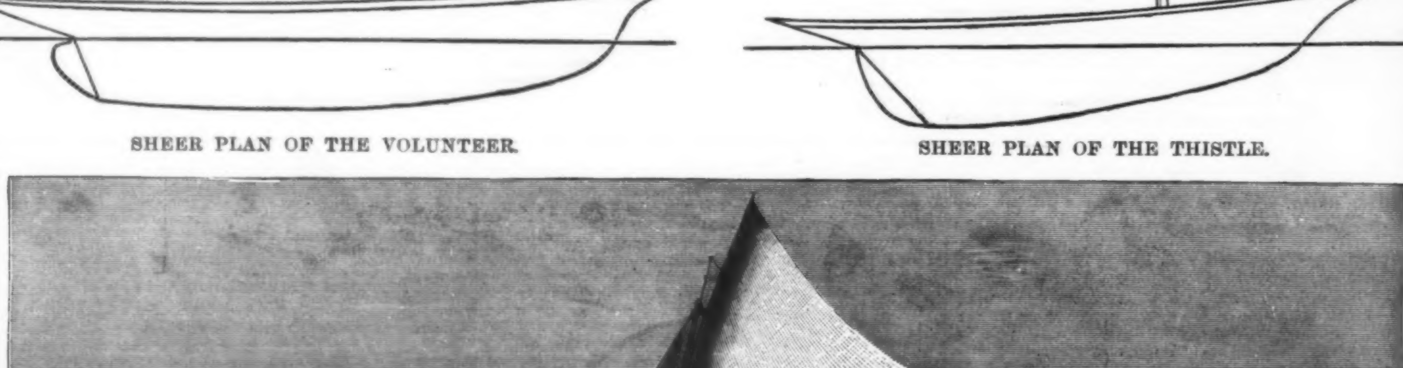
THE VOLUNTEER.



THE THISTLE.

SHEER PLAN OF THE VOLUNTEER.

SHEER PLAN OF THE THISTLE.



NEW AMERICAN STEEL SLOOP YACHT VOLUNTEER, BUILT TO COMPETE WITH THE BRITISH YACHT THISTLE FOR THE AMERICA CUP.

third, and twice not being placed. Thus her position was firmly established as the fastest yacht in England, the renowned Irex even having to acknowledge her superiority. The Thistle left England July 25, and reached New York August 16, making a 22 days' run.

Mr. Burgess, the builder of the Puritan and Mayflower, was engaged to model a new yacht to compete with the Thistle, if successful in the trial races. On April 1, Gen. C. J. Paine, of Boston, gave Mr. Burgess the order for the boat, and Pusey, Jones & Co., of Wilmington, Delaware, contracted to build her. The work was done with the utmost expedition. She was launched on June 30, and three weeks later made her first trial trip. She was named the Volunteer, and was built of steel.

The Volunteer spent the yachting season, up to the date of and after the arrival of the Thistle, in racing and cruising with other yachts, and it was generally acknowledged that she was by far the fastest boat in America. A trial race with the Mayflower was sailed on Sept. 16, when the Volunteer appeared so distinctly superior that she was at once chosen as defender of the America's cup.

Three races were appointed, the boat gaining two of

MIDSHIP SECTION OF THE VOLUNTEER.

the races being the winner. The first race, Sept. 27, was won by the Volunteer. It was sailed under the following official measurements, according to the certificate of Mr. John Hyslop, the measurer:

	Thistle. ft.	Volunteer. ft.
Length for tonnage	96·5	92·58
Length over all	108·5	106·23
Length on water line	86·46	85·88
Breadth of beam	20·3	23·16
Depth of hold	14·10	10·90
Tons, old measurement	253·94–95	209·8–95
For time allowance	89·20	89·35

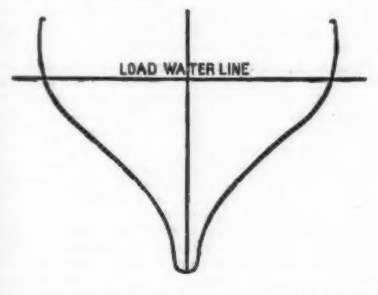
The Volunteer allows the Thistle five seconds.

The course was the inside course of the New York Yacht Club, from a point within the Narrows, down New York harbor, to and around the lightship, and return, following the main ship channel. The length of the course is 38 nautical miles (about 42¼ statute miles). The Volunteer came in over twenty minutes ahead, averaging a gain of nearly half a minute per mile, representing at the average rate of sailing in distance gained per mile about 370 feet. The actual space separating the two at the conclusion was about 2¼ miles.

The following is the official time:

Name.	Start. H. M. S.	Finish. H. M. S.	Elapsed Time. H. M. S.	Corrected Time. H. M. S.
Volunteer	12:34:58¼	5:28:16¼	4:53:18	4:53:18
Thistle	12:33:06	5:45:52¾	5:12:46¾	5:12:41¾

The second race, September 30, was sailed at sea, on the outside of New York harbor, course twenty miles to windward and return.



MIDSHIP SECTION OF THE THISTLE.

It was won by the Volunteer by the superiority of her windward work. In the run home before the wind the Thistle gained nearly three minutes on her rival. The following is the official time:

Name.	Start. H. M. S.	Finish. H. M. S.	Elapsed Time. H. M. S.	Corrected Time. H. M. S.
Volunteer	10:40:50¾	4:23:47	5:42:56¼	5:42:56¼
Thistle	10:40:21	4:35:12	5:54:51	5:54:44

The cup therefore remains here, the Volunteer coming in about two miles ahead in the second race.

We publish outline views of the two yachts and their sheer plans and midship sections, giving a good idea of their respective features and points of resemblance and difference.

A PATIENT'S ACCOUNT OF THE PASTEUR TREATMENT.

THE following letter, says the *Indian Medical Gazette*, was written by an Indian medical officer who was unfortunately compelled by the bite of a rabid dog to proceed to Paris and place himself under Pasteur's treatment:

"I am sending you a letter, as I think some account of M. Pasteur may interest you. I had a pleasant voyage home and got here on the 31st of January—good thing as I left M—— on the 12th of January. I was just in time, as Pasteur says his system is of no use after thirty days from the bite. I heard all about the dog that bit me. He had been queer, and refused all food from Saturday. On Sunday he bit me. On Monday he went raving mad, bit at every one and everything; bit his master, G—— of the ———Regiment at D——; a mehter and a Khit; then got paraplegia and was killed.

"They say here it was a typical and unmistakable case of rabies. I am sending you a paper with a very good account of the scene at Pasteur's laboratory. It really is a wonderful sight. Every age, sex, nationality, and rank there, from Lord Doneraile down to ragged Spanish peasants. There were over eighty being treated while I was there, and there were some new cases every day. They treat different cases differently. Bites on the face are more dangerous, and get a more prolonged course. I had to go and be inoculated morning and evening for six days; then every morning for five days. I was finished last Friday, but they asked me, if not inconvenient, to stay in Paris for five or six days more, and then report myself, when a few more inoculations *might* be necessary. After that they said: 'You can go with the most perfect confidence.' They begin with virus fourteen days old, and go on up to that only five days old; they don't use any stronger than that; but virus under seven days will infallibly give a dog rabies. It always burns a good deal, and the last few days gave me a pretty big subcutaneous lump and ecchymosed spot in the skin. Now, as to results. How any sane man can doubt but that Pasteur has made another great discovery is more than I can understand. But there is a great deal of jealousy—so French—among the doctors here, as he is only a chemist. But their line of argument is *so* weak. They can't prove that the treatment has ever proved injurious; but they say it is useless, and that there is no proof all his cases may not yet get hydrophobia, or they say they wouldn't have got it in any case. Now, look at facts on the other hand. He has now done just 3,000 cases, and only ten have got hydrophobia. Of these, eight were the famous Russians, but they came too late, and, besides, Pasteur said at the time his system was not worked out for wolf rabies, which is specially virulent, and has a very short period of incubation. These men came very late, and I think that only eight died out of the twenty-five speaks well for the treatment. They came very late, and their wounds were horrible. One man had his jaw nearly torn away, another his abdomen torn open, and one had a wolf's tooth so impacted in his skull that they could not get it out.

"Of the other two cases, one patient came 35 days after being bitten. Pasteur said it was too late, but he would try. The patient got hydrophobia, and died before the treatment was completed. The tenth was a man who came only two days, and then came no more—went on the spree about Paris. He got it, and died 50 days after the bite. Not one of all the others of the 3,000 have got it, and remember from 40 to 60 days after the bite is what they call the 'dangerous period.' Cases before 40 days are awfully rare, and very rare after 60 days, though up to 19 months are authentic. The vast majority are between 40 and 60. He only treats cases, too, where there is at least *strong* suspicion that the dog was mad. There are many cases such as the following: A young civilian named F. was sent to him six months ago. He is alive and well, but two cows bitten by same dog both died mad. A Spaniard came here who had been awfully torn by a huge Pyrennean dog. Among other injuries the whole of one calf had been almost torn away. The same dog bit another dog, a pig, and two cows; they all died mad, but the man is alive and well after seven months. Two children were bitten some time ago in England. One was sent here, the other not. The one who was treated is all right, the other died mad. Besides, he has in his laboratory a lot of dogs who have been inoculated, and you *can't* by any means give them rabies, even by means which infallibly give it to an unprotected dog, and the inoculation must in some way make you insusceptible, because the *last* inoculations are such as, if you hadn't been prepared, would be fatal; at least they are to *unprotected* dogs. I think there is but one conclusion to be drawn from these *facts.*"

COLOR BLINDNESS AMONG RAILROAD EMPLOYES.

By WILLIAM THOMSON, M.D., Professor of Ophthalmology in the Jefferson Medical College of Philadelphia.

THE conflict between the officers and the employes of the Reading Railroad, which has occupied recently the attention of the public, and has threatened to produce a suspension of work on that road, has reopened the question of color blindness among railroad employes, and led to a full demonstration of its existence among those engaged even as engine men, where the defect might lead to serious accidents, with loss of property and life. The officers of the road have selected the system for examination suggested by the writer, and employed to a full success for more than five years past on the Pennsylvania Railroad, and have appointed me to supervise its details, and, as ophthalmological expert, to decide all doubtful cases after careful examination of those found defective by the non-professional examiners of the company.

The conflict is nearly over, since demonstrations of the optical defect in engineers, made before a committee appointed by the employes, have satisfied them of the propriety of the testing, and that the safety of the traveling public demands the removal of all color-blind persons from positions where their optical defect might be the cause of distressing accidents. In the recent demonstrations I was able at my office to show that an engine man declared a red danger signal, made by placing red glass in front of a large gas light at a distance of two feet away, to be a green light. He was also not only unable to distinguish a red from a green flag within six feet, but he failed to classify the flags, white, red, green, and blue, properly, even when allowed to take them in his own hands.

The system adopted by the Reading Railroad is the one in use on the Pennsylvania Railroad, and owes its value to the fact that large bodies of employes can be brought under inspection and their defects discovered by non-professional examiners. It has been fully described in the *Medical News* of January 14, 1882, in the second edition of Nettleship's work on "Diseases of the Eye," and in a paper read before the American Association for Advancement of Science, in September, 1884, and in the *Popular Science Monthly* for February, 1885, and to those sources the reader is referred for further information.

Previous to its adoption by the officers and directors of the Pennsylvania Railroad, two thousand men were examined, and their blanks submitted to me, and the color-blind men sent to my office for final action. Mr. Pugh, General Manager, stated in September, 1884, that there were thus detected four per cent. of men color blind and ten per cent. of men deficient in acuteness of vision, and that, although it was very difficult to keep accurate notes of all examinations, he was satisfied that all dangerous persons had been removed up to that date, when over twelve thousand employes had been submitted to the system.

The statistics obtained upon the two thousand men were used as the standard by all the division superintendents, and however difficult it might be to report to the central office the full details of their examinations, they were always controlled by these known and accepted ratios. It has not been found requisite to send all men deficient to the ophthalmological expert, since they did not demand it, but submitted to the changes rendered necessary without opposition. Hence, I am unable to furnish exact reports of the examinations made at remote portions of the road. Most of the color-blind men have passed under my hands, as well as many cases of astigmatism, optical defects, and diseases or injuries reducing the sight below the standard, and the results may some time be found worthy of publication.

An opportunity to present the last opinions of the officers of the Pennsylvania Railroad has been afforded by a request which was made by the German government, through its minister, to the surgeon-general of the United States Army for statistical and other information on the subject, and this letter, referred to me by the surgeon-general, has been answered by Mr. Pugh, who has kindly made efforts to obtain the figures from the great organization of which he is general manager. He writes under date of July 7, 1887, and says:

"I regret that so long a time has elapsed since the receipt of yours of May 25 and its reply. The delay has been occasioned by our efforts to obtain some statistical information, which I regret to find has not been kept up as closely as was intended. I inclose herewith statements showing the number of employes examined during the past five years, with the results stated.

"I can only add that we have attained the most satisfactory results from the system, and I think we can confidently claim that sense of security which follows the belief that we have no one employed in any position, in which the use of signals is required, whose color sense and sense of vision will not enable him to accurately determine all signals by which his action is governed."

Total number examined on lines east of Erie	25,158
Color blind	481
Defective vision	661
Hearing	158

I am informed that the system has been found so satisfactory that it has been extended to the lines west of Pittsburg, and no doubt is now in use throughout all the lines controlled by the Pennsylvania Railroad, which employs over one hundred thousand men on its seven thousand miles of track.

It will be remembered that this system is also used to prevent the admission of defective men into the service, and that the apparently small percentage of color blind in this table may be ascribed to the non-application of men who know their deficiency, and to the fact that men in the service knowing their defect would leave the road before examination, and thus escape detection, and be enabled to gain employment on other roads where no examinations are required. Perhaps twelve or thirteen thousand was the number who were subject to examination by virtue of being in positions where color signals were used to direct them, in 1884, and the difference between that number and the total 25,000 would be made up of new men who would present a small ratio of those below the standard, since men conscious of color blindness or poor sight would not apply.

The fact that the intelligent officers of the Pennsylvania Railroad have adopted this system, purged their old force of all dangerous men, extended its use to all parts of their immense railroad, and now oppose it as a barrier to the admission of men thus unfit for service, is the best evidence that can be adduced to claim for it a successful place among the efforts to render scientific truths of practical value to the world. It is hoped that the Reading Railroad will be sustained in its contest with its employes by the example so quietly conducted by the Pennsylvania road, and that the reform, so necessary for the traveling public and for those employes who carry their lives in their hands daily, may be conducted to a happy finish.—*Med. News.*

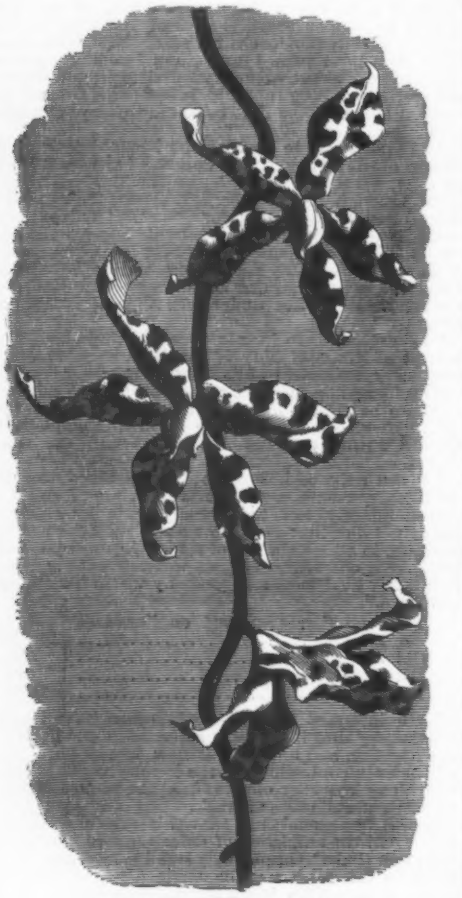
RENANTHERA LOWI.

THIS plant is better known in English gardens by the name of Vanda Lowi, and is often erroneously written Vanda Lowei. It differs from Vanda, however, in having its spur in the middle—not at the base of the lip—and in this organ being jointed at the base. It seems to be peculiar to the island of Borneo, where it is said to be found on trees and rocks in the hottest districts, and in the neighborhood of water.

In cultivation it is usually placed in the warmest part of the East India house, but recent observations lead me to believe that this species will thrive equally well and flower more freely in a much cooler temperature than is usually accorded it. A notable example of this is to be found in the collection of Mr. Measures at Cambridge Lodge, Camberwell, where there exists a grand specimen in the rudest health, which, for the last two years at least, has been subjected to a temperature not higher than 60° in winter, at which time, however, it must not be allowed to become dry. This plant is some 7 feet high, bearing twelve pairs of leaves of the richest green; it has two spikes of bloom, which, however, are not yet fully grown, and the flowers are not expanded. Another example is the famous plant from the once celebrated collection of Consul Schiller, near Hamburg. The plant has been for a long time in the possession of Mr. James, of Norwood, where it is certainly kept very cool, and its accommodation is far

from first rate. The plant is about 7 feet high, and in most robust health. It is producing several strong side shoots, from which a stock of home-grown plants may soon be expected. It is so difficult to import in good condition that it seems almost hopeless to expect to increase the numbers by these means. Mr. James' plant has flowered in the position it now occupies, the spike reaching some 12 feet in length, and it bore three yellow flowers at the base of the spike; the fourth basilar flower also was partly yellow, the usual number of these singular flowers being two only on each spike.

Renanthera Lowi, figured in the annexed engraving, was discovered by and named in honor of Sir Hugh Low, the brother of Mr. Stuart Low, of the Clapton Nurseries, and is an erect plant, with a stout stem; the leaves are arranged in a two-ranked manner; they are 1½ feet long, so that the plant measures upward of a yard from tip to tip of its leaves; the spikes are pendulous, and much longer than the plant. The flowers are dimorphous; the two basal ones are tawny



RENANTHERA LOWI.

yellow, ornamented with large crimson dots; the ground color of the other flowers is greenish yellow, transversely, banded with blotches of reddish brown. —*W. H. G.*, *The Garden*.

A PLANT HELIOSTAT.

The *Malva borealis* Wall. is a very common weed in cultivated ground throughout Southern California. It is an annual that quickly springs up in rich, tilled soil that is at all neglected. This "Malva," as it is appropriately called, is an almost constant stimulus to better culture, and stands ready to possess the soil, for a time at least, so soon as the harrow, gang plow, or hoe ceases to make frequent visits. The large areas in walnut groves, orange orchards, open fields for grain growing, and even along the roadsides, occupied by this weed made any observations as to its habits an easy task. The most interesting characteristic of this mallow which was noticed is the heliotropic power possessed by the foliage. The round cordate, neatly crenate, and more or less five to seven lobed leaves follow the sun during its daily course, and present their upper surfaces to the descending rays. The position of the blades is facing eastward in the morning, and as the day advances, the laminæ turn to the south and become more nearly horizontal. During the afternoon the blades approach the vertical position, and at sunset they face the western sky. In short, the malva leaves are living heliostats. This heliotropic movement is much more uniform in the leaves of young plants than in those that have grown old and woody. Over an area entirely covered with the malva plants that are about six inches high, and before any flowering stems have begun to shoot upward, the peculiarity of the leaves above noted is strikingly manifest to any person, however blunt his powers of observation, when once his attention is called to the matter.

A series of observations was made upon the movement of the leaves to determine, if possible, the portion of the blade that is most active in the turning, and also to discover the method of the return from the evening position to that assumed in the morning. By pushing small wooden stakes into the soil, and thus marking the position of a leaf at any given time, together with the use of strings tied upon the leaves, the changes could be determined. Frequent observations were required at all times of the day and far into the night. It was found that the point of torsion was located just below the blade, in a short portion of the upper end of the petiole. At this place, averaging a line in length in the most active leaves, the petiole is of different color and texture from the remaining lower portion of the long petiole. The fibro-vascular bundles here converge from their several strands into one central tough thread, and the surrounding soft tissue is similar to that of a pulvinus in nyctotropic and sensitive plants. The exterior of this portion of the petiole is of a reddish brown color. The blade effects its daily turning at this place, and when night comes on it returns to its morning position by retracing the path taken during the day. In no case was there any indication of any attempt to make an entire revolution. The backward movement begins as soon as the sun is set. In fact, the following of the sun is not so pronounced after three o'clock (and earlier on dark days) as up to that hour. It seems as if the sun drew the leaf around by its own attraction, and the blade moves back to its point of rest when the force is withdrawn.

There was no evident daily motion observed in the remaining portion of the long petioles. It is true that they varied their position from time to time, but with no regularity. Petioles on the eastern side of a plant remain more nearly horizontal than those located elsewhere. Those upon the north and south sides are more upright, with a tendency to point eastward. The western leaves are nearly upright, so that the blades may be able to catch the direct rays of the morning sun. At night there is an evident falling of the petioles as if to assume a position of rest, while the blades become nearly horizontal at the same time. By nine, or at most ten o'clock, in the evening the plant reached its position of repose, and an hour or more before the sun's morning rays can strike the plant the blades are all in position. Three distinct views of a malva patch may be obtained at any time when the sun is shining. If the view is, so to speak, from the sun, that is, in the direction of the rays of light, only the upper surfaces of the leaves are seen. If toward the direction of the sun, the under surfaces are in view. The difference between the shades of green of these two views is very marked. A third view is at right angles to the sun's rays, from which point the leaves are only seen by their edges, which are inclined from the perpendicular, the angle depending upon the height of the sun at the time of observation. Upon a dark, stormy day the heliotropism of the leaves is in a large degree suspended.

BYRON D. HALSTED.

Botanical Laboratory, Ames, Iowa.

—*Botanical Gazette.*

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